UNIVERSITY OF KENTUCKY

Purchasing Division

CAPITAL CONSTRUCTION

Request for Proposal
UK-2124-21

Proposal Due Date – 12/08/2020

Pavilion A – 5th Floor Patient Room Fit-Out

TC-189A - CONTROLS

Volume 3 of 4
Mechanical & Electrical Specifications

UK Project #2402.9

SECTION 20 0000 GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCE

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

1.2 DESCRIPTION

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

B. 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. Demolition:
   1. Division 02 - Selective Demolition.
   2. Perform demolition as required to accomplish new work.
   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.

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

F. Painting:

   1). Refer to 20 0553 Mechanical Systems Identification and 20 0700 Mechanical Systems Insulation for mechanical system pipe painting requirements.

   2). 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.

   3). Furnish equipment with factory applied prime finish unless otherwise specified.

   4). If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.

   5). Furnish one can of touch up paint for each factory finish that will be final finished surface of product.

   6). Painting of piping to follow UK Healthcare facilities Guidelines.

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.
   2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

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.
      a. Starters
      b. Disconnect devices
      c. Control devices:
         1). Pushbuttons
         2). Pilot lights
         3). Contacts
      d. Conduit, boxes and wiring for power wiring.
      e. Conduit, boxes and wiring for control wiring, except temperature control wiring.
   4. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor.
   5. Where starters or other similar control devices are furnished by this contractor, they shall be installed by this contractor and wired by Electrical Contractor.

6. Should any change in size, kW(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 for 1 year after acceptance by Owner.

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 00 – Substitution Request Form and 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 7mm(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.

V. In GMP clean room, Bio-safety and Wash down areas,
   1. Exposed conduit penetrations shall be sealed as follows:
      a. Escutcheons shall not be used when conduits are exposed in finished areas and penetrate finished surfaces.
      b. Cut and patch penetration to within 1/4" of conduit.
      c. Seal openings around conduit and patch work with sealants specified in Division 07 – Joint Sealants. Sealant shall be installed per manufacturer's application requirements.
   2. Penetrations other than conduits (junction boxes, light fixtures, etc.) including wiring devices shall be sealed as follows:
      a. Seal non-rated opening with silicone sealant.
      b. See Division 26 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.

3.5 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 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 LEAD SHIELDING

A. Wherever installation of this Contractor's equipment destroys radiologic 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.

3.11 MECHANICAL SYSTEMS IDENTIFICATION

A. Refer to Section 20 0553 - Mechanical Systems Identification

3.12 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.

3.13 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.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.14 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.

3.15 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.

3.16 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 20 0513 MOTORS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0514 - Variable Frequency Drive (VFD) System

B. Section 26 2913 - Enclosed Controllers

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 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)

1.4 PRODUCT CRITERIA

A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.

B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.

C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.

D. Motors located inside air handling units or exposed located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.

E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with starters specified hereinafter or under Electrical sections of Specifications.

1. Refer to Section 26 2913 - Enclosed Controllers for reduced voltage starting requirements.
2. Starters for NEMA rated 200 or 230 V motors, 25 HP and above shall be reduced voltage starting type.
3. Starters for NEMA rated 460 V motors,60 HP and above to be reduced voltage starting type.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 MANUFACTURERS

A. Siemens, U.S. Motors, Lincoln, Marathon, Baldor, or Cutler-Hammer (Westinghouse).

2.3 MOTORS

B. 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:

1. 460 V for operation on 480 V, 3 Ph, 60 Hz service.
2. 200 V for operation on 208 V, 3 Ph, 60 Hz service.
3. 230 V for operation on 240 V, 3 Ph, 60 Hz service.

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

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

E. 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.

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

G. 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.

H. Vibration shall not exceed 0.15" per second, unfiltered peak unless otherwise noted.

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

J. 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	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	88.5	89.5	85.5	89.5	89.5	86.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	95.4	95.8	95.0	95.8	96.2	95.8

K. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 HP and below may be shaded pole type.

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.

3.2 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 20-0514 VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

PART 1 GENERAL

1.1 RELATED WORK

A. Section 20-0513 – Motors

B. Section 23-0901 – Control System Integration

C. Section 23-0923 – Direct Digital Controllers and Networks

D. Section 23 0993 – Control Sequences

E. Section 26-2816 - Enclosed Switches and Circuit Breakers

F. Section 26-2913 - Enclosed Controllers

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SYSTEM DESCRIPTION

A. Mechanical Contractor shall provide redundant N+1, variable frequency drives (VFD) with integral manual transfer selector switch for each air handlers fan array, sized to accommodate motors horsepower’s as shown on drawings or schedules. Each drive to be feed from an independent power source. All VFD's shall be from same manufacturer. Manual transfer switch shall be located on load side of VFDs to prevent backfeeding power into load side of inactive VFD.

B. VFD manufacturer shall review driven equipment and motors for VFD compatibility. Submit written statement from manufacturer of driven equipment along with VFD shop drawing submittals, indicating verification of compatibility.

C. Contractor shall verify distance from motors to VFD's. VFD manufacturer shall provide sufficient equipment to assure proper operation and to avoid premature motor failure.

D. VFD manufacturer shall provide filter equipment as necessary to limit voltage transient ring wave stress placed on stator windings to withstand rating value of motors supplied per Section 20 0513 - Motors.

E. VFD shall vary speed of its respective fan, or other driven equipment motor in response to 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 input and output isolation contactors where VFD bypass starters are specified.
5. Line reactor
6. Step-up or step-down isolation transformer as required

1.4 QUALIFICATIONS

A. VFD system shall be furnished by, a manufacturer with at least 5 years experience in design, construction and application of VFD.

1.5 SUBMITTALS

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

B. After quality 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.

1.6 ELECTRICAL NOISE CRITERIA

A. Voltage and current distortion generated by VFD and attenuation devices measured at input and output of VFD assembly and as installed in place, shall not exceed the following criteria as referenced by IEEE Standard 519.
   1. Total harmonic distortion (THD) shall not exceed3%RMS of fundamental input voltage at full load with maximum 3% RMS on any single harmonic.
   2. Line voltage distortion shall not exceed 5% in amplitude of fundamental input voltage.
   3. Area of commutation notch (A_n) shall not exceed 16,400 voltmicroseconds measured at point of coupling to distribution system.

B. VFD manufacturer shall perform harmonic analysis at the input and secondary side of each distribution transformer to define submittals that compliance to IEEE-519-1992, Special Category, is attained. Analysis shall include electrical one line drawing defining resistance and impedance of each wire run and transformer leading to each VFD. Analysis shall be computer generated and perform Fourier analysis of the 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 power factors for distortion displacement, and total.

C. 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.

D. 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.

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

1.7 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 hrs of Owner training for each VFD system.

B. Should drive be deficient, drive manufacturer shall be required to make changes necessary to bring units into compliance with specified performance requirements. Cost of changes and retest shall be borne by drive manufacturer.

C. Upon completion of this service, submit a report, signed by manufacturer's service representative, including start-up and test log.

D. Manufacturer shall include additional 1 year (total 2 years) warranty for VFD system, covering parts, labor and travel expenses.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: ABB, Allen Bradley/Rockwell Automation, Cutler-Hammer, GE, Yaskawa (MagneTek), Reliance/Rockwell Automation, Square D, or Toshiba.

2.2 FABRICATION

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

B. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lock.

C. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.

D. Unit shall conform to NEMA and NEC standards and be CSA, UL or ETL listed. Control circuitry shall be electrically isolated from power circuitry. Entire assembly panel shall have UL or equivalent panel sticker.

E. Invertor section shall be pulse width modulated (PWM) design and third generation insulated gate bipolar transistors (IGBTs).

2.3 PERFORMANCE REQUIREMENTS

A. Input: 460 (+ 10%, - 5%) VAC, 3-phase, 60 (± 2) Hz.

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

C. Operating Environment Conditions: Ambient 0 to 40°C temperature, relative humidity up to 95% non-condensing.

D. Linear acceleration and deceleration adjustable from 5 to 60 seconds. Provide adjustable v/f ratio and low speed boost features.

E. Input harmonic distortion shall have true RMS (KW/RMSKVA) power factor greater than 90% at full load.

F. Output Current Rating: Continuous full load output current rating of drive shall not be less than that listed for motor of equivalent horsepower in NEC table 430-150.

G. Drive overload capacity to be minimum 110% of motor FLA based on NEC ratings for one minute.

H. Time to Shutdown: Inversely proportional to square of overload current ($t = k/I^2$).

I. Motor Regeneration Protection: Unit shall have capacity of dissipating regeneration energy without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.

J. Output Frequency Stability: ± 0.5% of base frequency in 24 hrs throughout range of rated operating conditions.

K. Output Voltage Regulation: ± 2% of maximum rated output voltage.

L. Output voltage rise time shall be no faster than 1000 volts/micro sec measured at the motor terminals. The voltage over shoot at the motor terminals shall be less than 250 volts.

M. Power Loss Ride-Through: 3 cycles or 50 milliseconds.

N. Linearity (speed reference to output frequency): ± 1.0%

O. Input Power Factor: Minimum of 0.95 regardless of speed and load.

P. The VFD and Bypass shall be UL listed for 100 KAIC without the need for input fuses.

Q. 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
75	97	96	94	90
50	97	96	94	90
25	96	95	91	84

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 potentiometer in manual mode.

B. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 30%.

C. Provide adjustable automatic reset for fault trips, except short circuit type faults. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selective.

D. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.

E. VFD shall be capable of starting into rotating loads spinning in any direction.

F. Provide critical frequency avoidance circuit with at least 3 field adjustable bands to avoid operation at speeds, which cause excessive vibration in driven equipment.

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

2.5 COORDINATION WITH BUILDING AUTOMATION SYSTEM (BAS)

A. Furnish each VFD with digital communication bus card for BAS use. VFD and Bypass shall be fully BACnet compliant without the use of integration gateways and shall utilize BACnet/MSTP or BACnet/IP communication protocols to communicate with BAS. Refer to Specification 23 0901 Control Systems Integration and 23 0923 Direct Digital Controllers and Networks for BAS and equipment controller architecture and Coordinate with Control Contractor for specific interface requirement.

B. Provide contacts (1 NO and 1 NC contact) for remote control of start/stop function for VFD mode and second set for bypass mode if bypass is specified.

C. Provide contacts (1 NO and 1 NC contact) for remote indication of VFD fault condition.

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 phase 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 MOVs for transient protection up to 3000 volts.
   2. Control circuit transformer fusing.
   3. Grounded control chassis.
   4. Diagnostic indication.
   5. One set of spare fuses for each type used in drive for each VFD.

D. Interlock VFD and Bypass control circuits with driven motor's disconnect switches where such motor disconnect switches are provided. Disconnecting on-line motor shall shut down VFD and Bypass. VFD and Bypass 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. Door interlock to disconnect VFD input power.

B. Manual stop/start device.

C. Operating mode selector device marked "Manual-Off-Automatic".

D. Manual speed control potentiometer.

E. Power on indication.

F. Drive run indication.

G. Drive fault indication with testable feature.

H. Fault reset device.

I. 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.

J. Integral digital programming and operating display which shows Hz, Percent Output Current, Output Voltage, Percent Output Power, 89 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.

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

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

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

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

O. VFD with Manual Bypass Starter:

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

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 40°C (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 device of the following:

1. Motor circuit switch: horsepower rated.
2. Enclosed molded case breaker; ampere rated and providing over current protection.
3. Molded case switch; ampere rated enclosed switch with or without over current protection.
4. Rotary switch: with or without fuser.

B. Unit shall have an interrupting rating not less than that of the upstream overcurrent device as shown on electrical drawings.

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

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

2.10 MOTOR CONTROL EQUIPMENT (BYPASS STARTERS)

A. Bypass starter shall be NEMA or IEC rated device of the following:

1. Electromechanical across-the-line starter with solid state overload protection for 50 HP or smaller.
2. Solid-state reduced voltage starter consisting of SCR based power section, logic control board and solid state overload protection for 60 HP or larger.

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 at 5% impedance and appropriately for total connected load. Design maximum temperature rise for inductors shall be 115°C.

B. Core shall be made of laminated grain oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core locked in place using vertical ties or rods.

C. Windings shall be copper wire, MW35C (round) or MW36C (rectangular) or copper foil. Terminations shall be tin plated copper alloy ring lugs, UL recognized terminal blocks, or solid copper bus. Terminations shall be pressure crimped or TIG welded to windings. Sheet insulation shall be DuPont Nomex 410 of thickness meeting UL insulation systems.

D. Inductors shall be double impregnated (vacuum/pressure impregnate and bake followed by varnish dip and bake). Insulation systems shall be rated Class H (180°C), 600 volt. Inductors shall be Hi-Pot tested (2500 volt, 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. Enclosure shall be steel with enamel finish and no knockouts. Enclosure shall be NEMA 1 construction with hinged lockable cover. Screened openings shall be provided for enclosure ventilation. Enclosure shall be built with integral mounting brackets for platform or wall mounting.

2.12 OUTPUT LC FILTER

A. Output 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 60Hz at nominal system voltages up to 600V. Filter shall operate at maximum carrier frequency of 8kHz at 40% of fundamental voltage. Ambient temperature of operation shall be 40°C.

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 115°C 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 DuPong 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), 600V.

2.13 ISOLATION TRANSFORMERS

A. Provide isolation transformer similar to Square D DIT type. Size transformer based on maximum kVA load of connected motor and in accordance with VFD manufacturer's recommendations.

B. Three phase transformers shall be 60 Hz, 480 volt delta primary and 480Y/277 volt secondary.

C. Transformers shall be air cooled, 2 winding type with minimum of four 2-1/2% full capacity primary taps, 2 above and 2 below full rated primary voltage.

D. Transformers 25 kVA to 112.5 kVA shall have 115°C temperature rise above 40°C ambient, allowing 15% continuous overload without exceeding 150°C rise in same ambient. Transformers above 112.5 kVA shall have temperature rise of 80°C above 40°C ambient, allowing 30% continuous overload without exceeding 150°C rise in same ambient.

E. Insulating material shall be in accordance with NEMA ST20 standard for 220°C UL component recognized insulation system.

F. Maximum temperature at top of enclosure shall not exceed 50°C rise above 40°C ambient.

G. Ventilation opening shall be designed to prevent accidental access to live parts.

H. Transformer coils shall be continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.

I. High grade silicon steel, non-aging with high magnetic permeability, low eddy current loses and low hysteresis is required of cores. Magnetic flux densities shall be below saturation point. Core laminations shall be clamped securely with sturdy steel members.

J. Provisions shall be made to isolate core and coil from enclosure with no metal-to-metal contact. Rubber vibration absorbing mounts shall be used to isolate base of enclosure from core and coil assembly.

K. Visibly ground transformer neutral to enclosure with flexible grounding conductor.

L. Entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with baked enamel.

M. Provide grounded shield between primary and secondary windings. Electrostatic shield shall consist of one-turn strip-copper winding placed between transformer primary and secondary winding. Insulate ends to prevent shorting. Lead from one end of shield shall run to transformer enclosure for grounding. Electrostatic shield shall not change primary and secondary winding insulation level to ground.

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 INSTALLATION

A. Install VFD system in accordance with details, approved shop drawings and manufacturer's instructions and recommendations.

B. Provide field electrical wiring, both line and low voltage of VFD system components, including interconnecting wiring between VFD and by-pass starter if bypass starter is specified. 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 and Bypass control circuits and driven motor's disconnect switches, where such motor disconnect switches are provided.

D. Provide ground conductor in addition to conduit ground for each motor circuit.

E. Do not connect ground from one unit to another unit's cabinet.

F. Use separate conduits for incoming and outgoing power conductors from each unit.

G. Use separate conduit for control wiring for each unit. Control wiring shall not occupy same conduit as power wiring.

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

I. Furnish 3 sets of air filters if unit is equipped with integral cooling fan.

J. Install floor mounted drives, on minimum 3-1/2" high concrete housekeeping pad and minimum 3/4" thick neoprene pad similar to Mason Super W, 50 durometer.

K. Install VFDs for air handling unit equipment on independent unistrut support structure. Do not mount VFDs on AHU housing.

L. Isolation Transformers:

1. Unless otherwise indicated, transformers below 75 kVA shall be wall or ceiling mounted. Transformers 75 kVA and above shall be floor mounted. Ample space shall be allowed for air circulation around all sides. Do not mount transformers below VFD equipment. Mount transformers above if conditions are tight.
2. Make all connections through enclosure at sides near bottom with vinyl covered flexible metal conduit in lengths not to exceed 3 ft.

3.3 START UP

A. Perform start-up of VFD in accordance with procedures as defined by manufacturer for proper operation.

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

C. At start up, factory trained engineer shall measure harmonic distortion attributable to VFDs and confirm compliance with IEEE 519-1992 and consistency with computer based harmonic distortion analysis from submittal. If harmonic distortion exceeds limits, adjust or replace filters and reactors until limits are met.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.4 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 20 0529 PIPING AND EQUIPMENT SUPPORTING DEVICES

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 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 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.

1.4 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

1.5 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.

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. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have vibration isolation hangers or supports as indicated above. Piping connected to coils, which are in equipment where fan assembly is separately isolated by vibration isolators and flexible connections, does not require additional vibration isolation hangers or supports. Refer to Section 23 0550 - Vibration Isolation for flexible connections, vibration isolators and additional requirements.

L. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.

M. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.

N. Unless otherwise indicated, continuous insert channels are not allowed.

O. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.

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

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

R. Coordinate with 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.

S. 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.

B. Supporting steel in clean rooms shall be stainless steel.

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)	---
Cold Pipes with Insulation (32°F) and below)	2” and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2” to 6”	260 (MSS Type-1)	171 (MSS Type-41), 181 (MSS Type-43)
	8” and larger		171 (MSS Type-41)

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

E. 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	B-Line BVT	---	---
	8” and larger	137 (MSS Type-24)		
Ambient Bare (Copper) pipes (60°F to 119°F)	all sizes	B-Line BVT		
	10” and smaller	137 (MSS Type-24)	---	---

Cold Pipes with Insulation (33°F to 59°F)	12” and larger	432	---	---
Cold Pipes with Insulation (32°F and below)	2” and smaller	243, 244	---	---
	2-1/2” and larger	---	171 or 177 (MSS Type-41), 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.

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 PIPE HANGERS AND SUPPORTS (NON-METALLIC)

A. Manufacturers: Aickinstrut, B-Line, Strut-Tech, Unistrut, Litchfield International, equal to B-Line figures listed

B. Clevis Type Hangers:

System	Pipe Size	Clevis
Uninsulated Pipe	1-1/4”and smaller	B-Line No. BFP22 SH series
		B-Line No. BFP22 SH series
	4” and smaller	B-Line No. BFP22 SH series

C. Clamp Type Hangers:

System	Pipe Size	Clamp	Cushions
Iron Pipe	1” and smaller	B-Line No. BFP-2000 Series	--
Steel Pipe	1” and smaller	B-Line No. BFP-2000 Series	--
Copper Tubing	1/2” and smaller	B-Line No. BFP-2000 Series	--

2.4 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" thru 6"	18"	16
8" thru 12"	24"	14
14" thru 24"	24"	12

2.5 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.

2.6 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):

1. 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 be100 psi.

D. Cold Pipes (59°F and below):

1. Cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas, maximum compressive strength 100 psi, rigid closed cell insulation (Type PP) similar to Trymer Green by ITW, maximum compressive strength for load calculation 30 psi, or expanded polyisocyanurate insulation (Type P) similar to Trymer 2000XP by ITW, maximum compressive strength for load calculation 30 psi.

2.7 PRE-INSULATED PIPE SUPPORTS

A. Shaw Pipe Shields, Inc., or Rilco, equal to Shaw 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 at 75°F mean temperature, minimum density of 13 lb/ft^3, and compressive strength not less than 100 psi.

C. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of 32 lb/ft^3 and minimum compressive strength of 600 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.

D. Use vapor barrier steel jacket around insulation. Insulation jackets shall be galvanized steel conforming to ASTM A-527. Hanger bearing surface shall consist of galvanized sheet metal insulation protection shield or casing.

E. When recommended by manufacturer, use double layer insulation protection shield at support bearing surface. Insulation shall extend 1" beyond insulation protection shield to maintain vapor barrier integrity.

F. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes and standards: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.

G. Load tests shall be made on both supporting materials and configurations. All tests shall be performed by independent testing laboratory. Results of pertinent tests shall be available upon request.

H. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Shaw Pipe Shields, Inc.
   1. Pipe supported on hangers: Models A2000, A4000, A9000, D3000 and D3200
   2. Pipe supported on flat surfaces: Models A2000, A4000, A6000, A7000, A7200, and A7400
   3. Pipe supported on pipe rolls: Models A4000, A6000, A8000, A8200, and A8400
   4. Pipe supported on slides: Model "B" Series
   5. A1000, A3000 or A5000 may be used for hot pipes (120°F and above)

I. Select proper model to conform to pipe service, support style, and support spacing.

J. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.

K. Pipe support spacing shall be in accordance with manufacturer's recommendations, but in no case shall exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.

2.8 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

D. Threaded rods are not allowed in clean rooms.

2.9 BOLTS, NUTS, STUDS AND WASHERS

A. ASTM A307, electroplated zinc finish

2.10 ROD ATTACHMENTS

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

2.11 U-BOLTS

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

2.12 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

2.13 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.

2.14 RISER CLAMPS

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

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

2.15 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.

2.16 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.

2.17 CONCRETE ANCHORS

A. Manufacturers: Hilti, Powers Fasteners or Red Head

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

C. Flush or shell type, meeting description in Federal Specification FF-S-325, Group VIII, Type 1 for expansion shield anchors, similar to Hilti Kwik Bolt TZ. Anchors shall be zinc plated in accordance with ASTM B633, Sc. 1, and Type III.

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. Select anchors with load ratings based on cracked concrete conditions.

2.18 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.

2.19 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.

2.20 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 CASEWORK PIPE SUPPORTS

A. Hinged pipe clamp and Strutcatcher, nylon 12 Grilamid, Clic by Litchfield International.

B. Vibration isolation pipe clamp, yellow zinc chromate finish, B-Line BVT Series Vibraclamp or Kwik-Clip by B-Line.

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.

J. Feed mains parallel to joists shall not be supported from single joist.

K. Feed mains parallel to joists shall be supported from trapeze hanger and be positioned equally between 2 joists.

L. Trapeze hangers shall be positioned to load joists at panel points only.

M. Top beam clamps shall be used in lieu of C-clamps when hanging 3" and larger pipe from top chord of roof trusses or top flange of beams.

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. Copper Tube (Unless Otherwise Noted):

Pipe Size	Max Spacing
3/4” and smaller	5’-0”

Pipe Size	Max Spacing
1" to 1-1/4"	6'-0"
1-1/2" to 2-1/2"	8'-0"
3" and larger	10'-0"

D. Copper Tube (Medical Gases):

Pipe Size	Max Spacing
1/4"	5'-0"
3/8" and 1/2"	6'-0"
3/4"	7'-0"
1"	8'-0"
1-1/4"	9'-0"
1-1/2" and larger	10'-0"

E. Plastic Pipe

1. PVC Pipe:

Pipe Size	Max Spacing
All sizes	4'-0"

2. CPVC Pipe:

Pipe Size	Max Spacing
1" and smaller	3'-0"
1-1/4" and larger	4'-0"

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

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 approximately midpoint of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at top and bottom of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
   3. Guide vertical piping 2" 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
   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. Support medical gas risers once per floor, not to exceed 15 feet.

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.

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 CONCRETE INSERTS

A. Concrete insert application, size, loading, and placement shall be this Contractor's responsibility and shall be reviewed and approved by the Structural Engineer prior to installation.

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

3.8 BEAM CLAMPS

A. Provide locknut for hanging rod at clamp.

B. C-clamps are allowed for rod size 1/2" 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.

3.9 TRAPEZE SUPPORTS

A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.

B. Determine trapeze supports spacing by the smallest pipe on trapeze.

3.10 PIPE MOUNTING PEDESTALS

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

3.11 CONCRETE ANCHORS

A. Anchor application, size, and placement shall be this Contractor's responsibility and reviewed and approved by the Structural Engineer.

3.12 PIPE ROOF PENETRATION PROTECTIONS

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

3.13 PIPE GUIDES

A. Install where shown on drawings.

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

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (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.

3.14 PIPE ANCHORS

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

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

END OF SECTION

SECTION 20 0553 MECHANICAL SYSTEMS IDENTIFICATION

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 SUBMITTALS

A. Product Data: For identification materials and devices

B. Valve Schedules: For each piping system

PART 2 - PRODUCTS

2.1 IDENTIFYING DEVICES

A. Marker System:
   1. Manufacturers: Brady USA, Marking Services Inc. (MSI), Kolbi, or Seton
   2. Manufacturer's standard, preprinted with color coding, lettering size and length of color field according to ASME A13.1.
   3. Use pressure-sensitive type or "snap-on" type.
   4. "Strap-on" type may be used for piping over 6” size including insulation.

B. Valve Tags:
   1. Minimum 2” diameter, 0.0625” thick, flexible, stain resistant, acrylic plastic equivalent to Setonply..

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.

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. Place flow directional arrows at each pipe identification location.

B. Identify all piping, except medical gas piping, not less than once every 15 ft above a ceiling system and every 10 ft in an open mechanical room, 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.

C. All plumbing and mechanical piping, except medical gas piping, shall be labeled, including sprinkler lines according to the following system:

University of Kentucky Standard Abbreviations for Mechanical Piping

Type of Service	Markings
High pressure steam & return (over 76 psig)	H.P.S. & H.P.R.
Medium pressure steam & return (21 psig to 75 psig)	M.P.S. & M.P.R.
Low pressure steam & return (0 psig to 20 psig)	L.P.S.& L.P.R.
Domestic cold Water	D.C.W.
Domestic hot Water	D.H.W.
Reheat supply & return	R.S. & R.R.
Chilled water supply & return	C.W.S. & C.W.R.
Cast iron soil & waste vents	W. & V.
Air (steel pipe)	AIR
Air (copper pipe)	AIR
Vacuum (copper pipe)	VAC
Vacuum (steel pipe)	VAC
Roof leaders	R.L.
Soft water	S.W.
Condensate pump discharge	COND. P.D.
Oxygen	OXYGEN
Fire suppression/sprinkler system	FIRE
Glycol solutions	GLYCOL

D. Identify piping with marker system.

1). For "strap-on" type, ensure marker is fitted snuggly to pipe or pipe insulation surface with sufficient straps.

E. Identify medical gas piping in accordance with NFPA 99 Chapter 5.1.11.

2). Pipe labels shall be located as follows:

a). At intervals of not more than 20 ft (6.1m).

b). At least once in every room.

c). On both sides of walls or partitions penetrated by the piping.

d). At least once in every story traversed by risers.

3). Piping shall be labeled by stenciling or adhesive markers that identify the patient medical gas, the support gas, or vacuum system and include:

a). The name of the gas/vacuum system or chemical symbol per Table 5.1.11.

b). The gas or vacuum system color code per Table 5.1.11.

c). Where positive pressure piping systems operate at pressures other than the standard pressure in Table 5.1.11, the labeling shall include the operating pressure in addition to the name of the gas.

3.3 VALVE AND DAMPER IDENTIFICATION

A. Identify valves and dampers with tags bearing system identification and valve sequence number in 1/2" black characters. Attach tag to valve body with brass SS jack chain or SS braided wires with swag sleeves and "S" hook. Non-metallic fasteners are not allowed. Valves and dampers located above the ceiling shall also be identified with a tag attached to the ceiling grid under the equipment or to access doors in non-accessible ceilings.

B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4" black letters.

C. Identify valves and dampers with the following abbreviations and tag colors:

Equipment	Abbreviation	Color
Valve	V.	Yellow
Terminal Unit	T.	Red
Variable Volume Unit	V.V.	Red
Heating Coil	H.C.	Blue
Cabinet Unit Heater	C.H.	Red
Fire Damper	F.D.	Black
Smoke Damper	SM.D.	Black
Combination Fire/Smoke Damper	FS.D.	Black
Volume Damper	VD	Black

D. Furnish typewritten valve schedule indicating valve number, fixtures, equipment or areas served by each numbered valve and incorporate in O&M Manuals.

E. Furnish typewritten framed chart under glass or clear plastic indicating fixtures, equipment or areas served by each numbered valve and mount same as directed by Architect.

3.4 STEAM TRAP IDENTIFICATION

A. Identify steam traps as specified for valve identification.

3.5 DUCT SYSTEM IDENTIFICATION

A. Install duct identification for each supply, return and exhaust air system.

B. Identify all ductwork not less than once every 25 ft and not less than once in each room.

C. Identify duct system by stenciling exterior of duct or insulation jacket by name as either “Supply Air (AHU-x), “Return Air (RF-x)”, or “Exhaust Air (EF-x)”. “-x” shall indicate system number (e.g. AHU-1).

D. Stencils shall be 2” (min) lettering, shall include direction arrow and shall be on bottom of duct or insulation jacket such that it is visible from floor below.

E. Do not identify systems exposed in architecturally “finished” spaces.

F. Hazardous ductwork shall have appropriate warning signs posted to protect personnel from exposure.

3.6 EQUIPMENT IDENTIFICATION

A. Identify major equipment, including air handling units, fans, boilers, chillers, heat exchangers, air terminal devices, pumps, water heaters, tanks, compressors, etc.

B. Equipment shall be named using PPDMC equipment naming convention. Wording shall be approved by PPDMC prior to installation.

C. Identify equipment with marker system.

D. Identify equipment with laminated plastic nameplates.

E. Identify control equipment and panels with laminated plastic nameplates.

F. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.7 ACCESS PANEL IDENTIFICATION

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

3.8 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.

END OF SECTION

SECTION 20 0573 MECHANICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 07 84 00 - Firestopping

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 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.

1.4 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. Firestopping systems and installations shall meet requirements of ASTM E-814, UL 1479 or UL 2079 tested assemblies that provide fire rating equal to that of construction being penetrated. Air leakage rate of joints shall not exceed 5.0 cfm per lineal foot of joint at 0.3 inch of water for both the ambient temperature and elevated temperature tests.

C. Firestop materials and methods shall conform to requirements of Local Code Authority Having Jurisdiction.

1.5 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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.

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.

D. Materials shall not contain flammable solvents.

E. Materials shall be red in color.

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.

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

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

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

D. 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

SECTION 20-0700 MECHANICAL SYSTEMS INSULATION

PART 1 GENERAL

1.1 RELATED WORK

A. Section 20-0529 - Piping and Equipment Supporting Devices

B. Section 23-3114 - Ductwork

1.2 REFERENCE

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

1.3 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.

1.4 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)/(hr ft^2 °F).

C. Interstitial spaces are considered as concealed areas.

1.5 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. All other appropriate data

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

2.2 MATERIALS

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

B. Unless otherwise indicated, all products, material itself or on a composite basis, shall meet ASTM E-84, UL 723 or NFPA 255 and shall not exceed 25 flame spread and 50 smoke developed.

C. Outdoor insulation may have flame spread rating up to 75 and smoke developed rating up to 150.

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

2.3 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/ft^3, 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/ft^3, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.

E. Type F Insulation (Flexible Glass Fiber):

1. Minimum density of 0.75 lb/ft^3 with thermal conductivity of not more than 0.27 at 75°F mean temperature, and suitable for temperatures to 250°F. Owens Corning "All Service Duct Wrap", Johns Manville Microlite.

F. Type R Insulation (Rigid Glass Fiber):

1. Minimum nominal density of 3 lb/ft^3, with thermal conductivity of not more than 0.23 at 75°F mean temperature. Minimum compressive strength at 10% deformation shall be 25 lb/ft^2.
2. Pipe insulation shall be suitable for temperatures to 850°F, Johns Manville Micro-Lok 850, Owens Corning Fiberglas ASJ/SSL-II.
3. Duct and equipment insulation shall be suitable for temperatures to 450°F, Johns Manville Spin-Glas Type 814, Owens Corning Type 703.
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.

G. Type RR Insulation (Rigid Glass Fiber):

1. Minimum nominal density of 6 lb/ft^3, 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/ft^2, Johns Manville Spin-Glas Type 817 or Owens Corning 705.
2. 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.

H. Type P Insulation (Expanded Polyisocyanurate):

1. Continuously molded rigid foam insulation meeting requirements of ASTM C-591, with thermal conductivity of not more than 0.19 at 75°F mean temperature, minimum density of 2 lb/ft^3, minimum compressive strength of 24 psi, maximum water vapor transmission of 4.0 perm-inch, and suitable for temperature of plus 300°F down to -297°F. Insulation shall have factory-applied jacket with SSL. Dow Chemical Trymer 2000 or approved equal.
2. Koolphen K phenolic foam insulation by Kooltherm Insulation or Apache ISO 25 series 200 may be used provided insulation characteristics equal or exceed requirements specified for Type P.

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/ft^3 minimum and compressive strength 100 psi. Industrial Insulation Group (formerly Johns Manville), Thermo-12 Gold.

J. Type A Insulation (Closed Cell Elastomeric Thermal Insulation):

1. Minimum nominal density of 6 lb/ft^3 ,thermal conductivity not more than 0.28 at 75°F mean temperature, maximum water vapor transmission of 0.08 perm-inch and suitable for temperatures from -70°F to 220°F, Armacell Model AP/Armaflex, Nomaco Model K-Flex, or Aeroflex Model Aerocel.

K. Type T Insulation (Mineral Fiber Fireproofing):

1. Nominal 8 lb/ft^3 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, service temperature to 1200°F. US Gypsum Thermafiber, Roxul or Fibrex duct insulation.

L. Type FR Insulation (Fire Resistive Duct Wrap)

1. Wrap material shall be Fire Master Fast Wrap + duct wrap by Thermal Ceramics or approved equal. 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. 0" clearance to combustible, maximum allowable surface temperature on unexposed side, UL1978
   b. Class 1 interior finish materials, ASTM E84
   c. Through-penetration protection systems for air ducts, ASTM E814 and UL 1479
   d. Non-combustibility, ASTM E136
   e. ISO-6944-1985, Fire Resistance Tests - Ventilation Ducts

M. Type KG Insulation (Kitchen Grease Duct Wrap):

1. Wrap material shall be suitable for kitchen grease duct wrap meeting IMC 2006 and shall be Fire Master Fast Wrap XL by Thermal Ceramics or similar products by UniFax or 3M. Wrap shall be two layers, each 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. 0" clearance to combustible, maximum allowable surface temperature on unexposed side, UL 1978.
   b. Class 1 interior finish materials, ASTM E84.
   c. Through-penetration protection systems for air ducts, ASTM E814 and UL 1479.
   d. Non-combustibility, ASTM E136.
   e. Passes ASTM E2336 test standard.

N. Type M Insulation (Mineral Wool Pipe Covering):

1. Mineral fiber premolded pipe insulation, in accordance with ASTM C-547, Type II, Grade A, nominal 8 lb/ft^3 density, water resistant, non-wicking, suitable for continuous temperature through 1200°F, thermal conductivity not more than 0.41 at 400°F mean temperature, Fibrex Coreplus 1200, Roxul 1200 or IIG MinWool-1200.

O. Type G Insulation (Cellular Glass):

1. 100% cellular glass cells with no organic material, noncombustible, 0.00 perm-inch permeability, 8 lb/ft^3 average density, compression strength 100 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.

P. Type S Insulation (Polystyrene Pipe Insulation):

1. Nominal 1.6 lb/ft^3 density, thermal conductivity not more than 0.26 at 75°F mean temperature, compressive strength 20 psi based on 10% deflection, water vapor transmission 1.5 perm-inch, water absorption 0.5% by volume.

2. Manufacturers: Dow Chemical Styrofoam brand insulation Billet or approved equal.

Q. Type C Insulation (Ceramic Fiber):

1. Formed from alumina and silica materials, nominal 8 lb/ft^3 density, suitable for temperature to 2000°F continuous, thermal conductivity not more than 0.93 at 1000°F mean temperature, equal to Thermal Ceramics Cerablanket or Kaowool.

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 P-1 Jackets:

1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be 0.0005" aluminum foil adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ-SSL", Johns Manville flame-safe "AP-T".

C. Type D-1 Jacket:

1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be 0.0005" aluminum foil adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ", Johns Manville "AP".

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".

E. Type D-3 Jacket:

1. Self-adhering, multiple laminated waterproofing material with reflective aluminum foil, high density polymer films and minimum 40 mil rubberized asphalt waterproofing compound, similar to Peel and Seal or Flex Clad 400 by MFM Building Products Corp. or Alumaguard 60 by Polyguard. Products shall carry minimum 10 yr manufacturer's warranty.

F. Type E-1 Jacket:

1. Glass fiber reinforcing fabric imbedded in weather barrier mastic as per manufacturer's recommended procedure for 2 coat application.

G. Type E-2 Jacket:

1. Heat sealable, multi-ply laminate consisting of layer of asphalt, glass fiber reinforcement, second layer of asphalt, aluminum foil layer, third layer of asphalt, and polyester outer film. Pittsburgh Corning Pittwrap. Minimum total thickness shall be 125 mils.

2. Self-sealing, non-metallic sheet consisting of special bituminous resin reinforced with woven glass fabric and 1 mil thick aluminum film. Pittsburgh Corning Pittwrap SS. Minimum total thickness shall be 70 mils.

H. Type E-3, Jacket

1. Self-sealing, modified bituminous membrane reinforced with glass fabric and 1 mil thick aluminum film. Pittsburgh Corning Pittwrap CW Plus. Minimum total thickness shall be 50 mils.

I. Type V-1 Jacket:

1. Fire retardant and UV resistant PVC in minimum 20 mil (0.02") thickness consisting of preformed fitting covers, preformed end terminations, and sheet material for straight runs of pipe. Material when installed according to manufacturer's instructions shall provide complete vapor barrier and readily cleanable surface while meeting Federal CGMP requirements.

2. Jacketing system shall be equal to Johns Manville Zeston/Perma-Weld System. Similar product by PROTO will be acceptable.

J. Type A-1 Jacket (Protective Insulation Shield):

1. Factory fabricated .016" thick, ASTM B209, Type 3003 or 1100, stucco embossed aluminum jacket with integrally bonded polykraft moisture barrier, complete with integral longitudinal Pittsburgh Z-Lock seam.

2. Fitting covers shall be factory fabricated from not lighter than 0.024" thick, Type 3003 or 1100 aluminum.

3. Jacketing system shall be equal to Childers Lock-On.

K. Type S-1 Jacket (Protective Insulation Shield):

1. Factory fabricated .01" thick, ASTM A-240, 304 stainless steel, 2B mill finish jacket with integrally bonded polykraft moisture barrier, complete with integral longitudinal Pittsburgh Z-Lock seam.

2. Jacketing system shall be equal to Childers Lock-On.

L. Type S-2 Jacket:

1. Saran Vapor Retarder Film with self-sealing lap (SSL), ASTM C-755 and C-1136, 6 mil thickness. Permeance shall not exceed 0.01 perms, equal to Dow Saran 560.

2. Elbows, fittings, valves and butt joints shall be wrapped with 3 layers of Dow Saran 520 Vapor Retarder tape.

3. Provide PVC jacket (Type V-1) over Saran tapes for exposed elbows, fittings and valves.

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

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

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

C. Adhesives, mastic, sealants, and protective finishes shall be as recommended by insulation manufacturer for specified application.

D. Glass fiber fabric reinforcing shall be 10 x 10 or 20 x 10 mesh.

E. Wire mesh reinforcing shall be 22 ga, 1" galvanized.

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

G. Finishing cement shall be ASTM C449.

H. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373 or Manville 57.

I. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish.

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 REMOVABLE INSULATING BLANKETS

A. Custom designed removable, reusable, flexible, blanket thermal insulation system.

B. Acceptable Manufacturers: Thermal Energy Products, Inc., Advanced Thermal Corp. 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/ft^3 density, 1000°F thermal insulating wool; Owens Corning Fiberglass or equal.

F. Interior and Exterior Fabric: 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.

2.8 ACOUSTICAL BARRIER MATERIALS

A. Acoustical barrier material shall be similar to Kinetics Model KNM-100B or EAR Lag-10. Barrier material to have acoustic ratings of STC-26, 1.0 lb/ft^2 weight, and minimum continuous operating range from -10 to 180°F.

B. Minimum sound transmission loss at each octave band shall be as follows:

Sound Transmission Loss (dB)

Octave Band Center Frequency (Hz)

125	250	500	1000	2000	4000
15	16	21	26	33	38

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.

Piping System

Service	Jacket Type	Insulation Type	Insulation Thickness According to Pipe Size				
			3/4" and less	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Heating Hot Water (141-200°F)	P-1	R	1"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
Chilled Glycol	P-1	R	1.5"	1.5"	2"	2"	2"
Chilled Water	P-1	R	1.5"	1.5"	2"	2"	2"
Cooling Coil Condensate Drain	P-1	R	1"	1"	1"	1"	1"
Low Pressure Steam and Condensate Return	P-1	R	1-1/2"	1-1/2"	2"	2"	3-1/2"
Domestic Cold Water	P-1	R	1"	1"	1"	1"	1"
Domestic Hot Water and Hot Water Return (105-140°F)	P-1	R	1"	1"	1-1/2"	1-1/2"	1-1/2"

Chilled Water Piping in Air Handling Unit Housing	Provide V-1 jacket in addition to insulation jacket specified in this schedule.

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"
Mixed Air (Outside Air & Return Air Ducts & Plenum)	D-1	R	1-1/2"
Supply Ducts Exposed	D-1	R	1-1/2"
Supply Ducts Concealed	D-2	F	1-1/2"
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"

B. Exposed piping in any room and all piping in boiler or mechanical rooms shall have an 8 ounce canvas jacket applied over the fiberglass factory ASJ/SSL jacketing to further protect the insulation from abuse. This jacketing must be properly applied with lagging adhesive, such that the outer surface is smooth and free of wrinkles. All chilled water piping insulation shall be completely sealed so that a perfect vapor barrier is achieved.

C. As an alternative to canvas jacket for exposed piping or piping subject to abuse in mechanical spaces, Type V-1 jacket may be used where surface temperature of insulation is lower than 125 deg F.

D. Type F insulation with Type D-2 jacket may be used in lieu of Type R insulation with Type D-1 jacket for ductwork located 12 ft or higher above floor in mechanical equipment rooms. Horizontal ducts that are not completely 12 ft above floor shall be insulated with Type R insulation as specified for its entirety with the exception of the Surgery AHU supply plenum which may utilize Type F insulation with Type D-2 jacket.

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 20 000 - General Mechanical Requirements and Section 20 0573 - Mechanical Systems Firestopping.

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

K. Insulate the following systems for complete vapor barrier protection:

1. Chilled Water
2. Cooling coil condensate drain
3. Cold Water
4. All insulated ductwork
5. All equipment with surface temperature below 65°F

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

3.3 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 hrs.

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.

B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.

C. Cover joints with factory furnished tape (3" minimum width) to match jacket. Cement firmly with lap adhesive.

D. Secure insulation, except insulation covered with vinyl jackets, additionally with staples.

E. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.

F. Built-up insulation for fittings and valves shall be made with sectional insulation, wrapped firmly to thickness of adjoining pipe insulation, and bound with jute twine, or built up with insulating cement, and finished to smooth hard surface, and covered with minimum of 9 oz per sq yd rewettable glass cloth similar to Clairmont Diplag 60.

G. For valves and fittings requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For valves and fittings not requiring vapor barrier, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.

H. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, one piece PVC fitting covers, minimum thickness of 20 mil, may be used. Fitting covers located in mechanical rooms within 8 ft above floor shall be 30 mil thickness. Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match those of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.

I. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.

J. For pipes 1-1/2" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.

K. For pipes 2" and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. Use 3" wide vapor barrier tape on hot and cold systems at pipe supports.

L. For pre-insulated pipe supports and insulation protection shields, refer to Section 20 0529 - Mechanical Supporting Devices.

M. For contractor-fabricated anchors, secure insulation directly to pipe surface and extend insulation up anchor for distance of 4 times insulation thickness. For pre-insulated anchors, cover entire surface of anchors with Type A insulation. Where applicable, take special care to assure vapor seal at anchor.

N. Where mechanical grooved pipe connections are used in piping system, insulate couplings as specified for pipe.

O. Piping, fittings and valves not to be insulated:

1. Heating hot water piping inside fin tube radiation enclosures
2. Control valves and balancing valves for heating terminal devices
3. Valves furnished with removable insulation/jacket
4. Steam system traps

3.5 EQUIPMENT INSULATION

A. Apply insulation to equipment shells with bonding adhesive and wire in place. Fill joints and seams with insulating cement and cover insulated surfaces with wire reinforcing mesh. Apply additional coat of insulating cement, cover with glass fabric as specified herein, and finish to smooth hard surface.

B. For equipment shells requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For equipment shells not requiring vapor barrier,

apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.

C. For equipment requiring Type H, Type M or Type C 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.

D. Install removable insulating boxes where access is required for cleaning, repair and inspection, including pump heads and strainers. Construct removable insulating boxes with split metal enclosures using minimum 24 ga galvanized sheet metal lined with Type A insulation adhered to inside of box with 520 adhesive. Do not apply bonding adhesive to equipment surface. Finish interior surface of insulating box to allow removal without damage. Provide fasteners, supports and membranes as required.

E. Provide Removable Insulating Blankets on expansion joints.

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

G. Water chiller insulation shall include insulation of evaporator shell, water boxes and other miscellaneous piping and/or equipment as directed by equipment supplier. Provide removable insulating boxes at chiller water boxes. Verify that chillers are fully charged with refrigerant before insulating.

H. 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.

B. For support points of rectangular ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be the same thickness as insulation specified, the full width of the duct and a minimum of 6" long.

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

D. For support points of round ducts 16" diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6" long with same thickness as insulation specified and shall be similar to HAMFAB H-block by ICA Inc.

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

F. Secure flexible glass fiber insulation (Type F) to underside of horizontal rectangular or oval ductwork 24" in width or greater and on vertical sides of horizontal and vertical ductwork with weld pin or mechanical fasteners not over 18" on center and within 3" of butt joint or edge.

G. Secure rigid glass fiber insulation (Type R or Type M) to all sides of horizontal and vertical rectangular or oval ductwork with weld pin or mechanical fasteners. Install pins or fasteners as required to secure, but not less than 12" on center for underside and sides of ducts and 24" on center for top of ducts, and within 3" of butt joint or edge.

H. Clip pins fastened to ductwork with adhesives are not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Clip pins neatly back to each fastener.

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 shall be jacketed over with matching material. Where staples are used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.

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 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 and finish with 2 coats of vapor barrier mastic.

O. D-2 jackets:

1. Butt together joints and seams firmly and cover with 3" 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 along side 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 pace on stick pin.

Q. Kitchen Exhaust Ducts:

1. Insulate kitchen exhaust ducts except those exposed in kitchen. Impale insulation over weld pins on 12" centers longitudinally and 9" centers in transverse direction. Fasten with steel speed washers 0.019" x 2-1/2" x 2-1/2". Butt insulation edges tightly together and seal joints with 3" tape adhered and stapled with flare type staples on 4" centers.

R. Ductwork not to be insulated:

1. Internally lined ductwork
2. Ductwork components with factory installed insulation

3.7 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.

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.

3.8 TYPE S INSULATION (POLYSTYRENE)

A. Pipe:

1. Use sectional insulation (semi-circular form) for pipe sizes 10" and smaller. Use segmental or sectional insulation for pipe sizes above 10".
2. Plain sectional insulation shall be applied so that end joints are broken by making one-half of first section 18" long and leaving other half 36" in length. Longitudinal joints shall be on top and bottom of pipe. Apply insulation with sealer such as Benjamin Foster's 30-45 Foam-seal on joints of single layer and outer layer insulation with band placed approximately 3" or 4-1/2" (see band schedule) back from end joints. Do not cement insulation to pipe. Omit joint sealer from inner layer of double layer insulation.
3. Plain insulation lagging (blocks) for segmental insulation may be factory fabricated or beveled lagging assembled on job. Lags shall fit pipe snugly and maximum width of each lag shall be such as to leave not more than 1/8" void between pipe and joints of segments. Joints shall be broken by, starting with alternating 18" and 36" lags. Apply sealer and bands same as specified for plain sectional insulation.
4. Apply pipe insulation in double layer construction with joints staggered (2 layers at 1" thick each).

B. Fittings, Valves and Flanges:

1. Insulation at fittings shall not be of less thickness than insulation on adjacent piping. Fitting insulation (covers) shall be held together and applied with sealer. Insulation on welded fittings shall fit snugly to fitting contour and shall be applied in same manner and with same materials as specified for pipe.
2. Apply fitting insulation with sealer on joints and band insulation in place using not fewer than 2 bands on threaded fittings and 4 bands on flanged fitting.
3. Insulate threaded fittings before straight pipe is covered. Insulate flanged fittings after straight pipe is covered.

C. Band Material:

1. Secure single layer or outer layer insulation with stainless steel bands, 6" spacing for insulated outside diameter under 12" and 9" spacing for 12" and over.
2. Secure inner layer insulation with stainless steel bands 9" spacing.
3. Tighten bands with mechanical tightening tool and secure with 304 stainless steel wing type seals.

D. Vapor Barrier and Jacket:

1. Finish plain pipe insulation, fittings, valves and flanges with vapor barrier mastic.
2. After thoroughly dry, apply service jacket (Type P-1) and insulation shield jacket (Type A-1).

END OF SECTION

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SECTION 21 0000 GENERAL FIRE SUPPRESSION REQUIREMENTS

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 0529 - Piping and Equipment 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 1314 – Automatic Fire Sprinkler System

G. Section 26 0593 – Electrical Systems Firestopping

H. Section 28 3116 – Multiplexed Fire Detection and Alarm Systems

PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

EXECUTION

2.2 NOT APPLICABLE TO THIS SECTION.

END OF SECTION

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SECTION 21 1314 AUTOMATIC FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies materials, methods, and equipment to be used for automatic sprinkler system and related fire protection piping for first floor PAV A – Interventional fit out.

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. As shown on drawings, system(s) shall consist of renovation of existing systems:
   1. 2 automatic fire sprinkler zone(s) which consist of:
      a. 2 wet sprinkler zone(s)

E. 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.

F. 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.

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

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

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

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

1.2 RELATED WORK

A. Section 20 0000 – General Mechanical Requirements

B. Section 20 0529 – Piping and Equipment 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 26 0593 – Electrical Systems Firestopping

H. 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
      b. NFPA 25, Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
      c. NFPA 72, National Fire Alarm and Signaling Code
      d. NFPA 99, Health Care Facilities Code
      e. NFPA 101, Life Safety Code
      f. Underwriters Laboratories (UL) Fire Protection Equipment Directory
      g. Factory Mutual Global (FMG) Property Loss Prevention Data Sheets
      h. Lexington – Fayette Urban County Code of Ordinances
      i. Kentucky Building Code (KBC), 2002 Edition, with KBC Supplement, 2003 Edition
      j. Kentucky Fire Code (KFC), 2000 Edition
      k. American Institute of Architects Academy of Architecture for Health (AIA), 2001 Guidelines for Design and Construction of Hospital and Health Care Facilities
      l. University of Kentucky Design and Construction Guidelines
      m. University of Kentucky Health Standards
      n. University of Kentucky Safety and Security Standards
      o. University of Kentucky Campus ADA Standards
      p. Occupational Safety and Health Administration (OSHA)

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 Kentucky 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.

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. Sprinkler Heads
4. Sprinkler Head Cabinet
5. Hanger Assemblies
6. Drawings
7. Hydraulic Calculations

B. Submit Material Safety Data Sheet (MSDS) for corrosion inhibitive paint.

C. Include items listed in product section and additional items required to provide complete installation.

D. Indicate by red marking or arrow, items that are to be provided, where more than 1 item appears on manufacturer's catalog sheet.

E. Submit stamped and sealed drawings, product datasheets, hydraulic calculations, and a signed copy of the Owner’s certificate to the local fire department, Engineer, and Owner's insurance representative prior to installation or fabrication of system components.

F. Submit stamped and sealed drawings, product data sheets, and hydraulic calculations to the University Fire Marshall and local Fire Department prior to installation or fabrication of system components.

G. Include copy of the University Fire Marshall and local Fire Department plan review letters in submission to Engineer.

H. Prior to installation or fabrication of system components, submit layout drawings and equipment submittals to Engineer of Record.

I. After review of layout drawings by Engineer of Record, submit drawings and calculations to the University Fire Marshall, local fire department, and Owner's Insurance Representative.

J. Review of submittals does not relieve Contractor from coordinating installation of work with other trades, or from compliance with Codes and Standards.

K. At completion of acceptance tests:
   1. Send copy of test log to Engineer
   2. Send copy of Contractor's Material and Test Certificates 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.
      e. Current copy of NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

PART 2 - PRODUCTS

2.1 MATERIALS

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

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

2.2 PIPE

A. Above Ground:
   1. Carbon Steel, all sizes:

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 or cut grooved for mechanical coupling, 175 psi CWP rating, malleable iron conforming to ASTM A47.

a). Acceptable manufacturers: Anvil Gruvlok, Tyco Grinnell, Victaulic, Viking

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”

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. Provide metal pipe’s exposed threads with corrosion inhibitive paint, equal to Rust-Oleum.

3. 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.

4. Plain end couplings (Roust-A-Bouts, Plainloks or similar couplings) are not allowed on either new or existing sprinkler systems.

5. Adjustable drop nipples are not allowed on either new or existing sprinkler systems.

6. Expansion joints:

a. Provide 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.

7. 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. Ball Valve:

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

B. Air Release Valve:
1. Acceptable manufacturers: Engineered Corrosion Solutions, Potter Electric Signal Co.
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.
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.

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

D. Valves in galvanized piping shall be bronze.

2.4 SPRINKLER HEAD

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

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

C. Light Hazard occupancies shall utilize quick-response type sprinkler heads.

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

E. Provide the following type of sprinkler head.
1. Type A: Unfinished areas.
a. Standard Coverage, Brass Upright or Pendent, ordinary temperature class, Tyco Fire Products Model TY-FRB, Viking Microfast, or equal.
2. Type B: In areas with ceilings.
a. Standard Coverage, ordinary temperature class, Viking model VK302 or equal.
3. Type C: 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 chrome finish, ordinary temperature class, Tyco Fire Products Model TY-FRB, Viking Microfast horizontal (HSW) or vertical (VSW) sidewall with Viking Microfast Model F-1 adjustable escutcheon, or equal.
4. Type D: Around curtain tracks I patient rooms.
a. Standard Coverage, Concealed Pendent, ordinary temperature class, 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).

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

G. 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.

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

I. 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.

2.5 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.

2.6 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. Basis of Design:
   1. Office areas and general building spaces shall be hydraulically designed to provide minimum density of 0.10gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 225 sq ft per head.
   2. General storage areas shall be hydraulically designed to provide minimum density of 0.20gpm per sq ft over most hydraulically remote 1500 sq ft. Maximum spacing shall not exceed 130 sq ft per head.

B. Hose Streams:
   1. Add 100 gpm hose stream to sprinkler zone hydraulic calculations for Light Hazard Occupancies.
   2. Add 250 gpm hose stream to sprinkler zone hydraulic calculations for Ordinary Hazard Occupancies.

C. 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 systems in 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: local Fire Department, Engineer, Architect, Owner's insurance representative, City of Lexington 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 pipe, fittings, couplings, and valves according to requirements of manufacturer.

C. Provide nonferrous metal pipe in MRI area(s).

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. Above Ground Pipe:
   1. Provide pipe identification system with flow directional arrows on fire protection pipe in accordance with manufacturer's installation instructions. For additional information, refer to Section 20 0553 – Mechanical Systems Identification.
   2. Coat exposed threads with corrosion inhibitive paint, equal to Rust-Oleum. Apply paint per manufacturer's instructions.

G. Provide readily removable fittings at end of cross-mains. Minimum size of flushing connection shall be 2".

H. Provide test connection for each flow switch.

I. Provide auxiliary drains at low points of systems per requirements of NFPA 13.

J. Identify valve with brass tag denoting which flow switch is being tested, when test valves are located remote from flow switch.

K. 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.

L. 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.

M. Feed sprinkler heads, installed in finished ceilings, with swing joint, or return bend arrangement for final positioning in ceiling grid pattern during construction phases.

N. Sprinklers **are** required to be installed in the center of ceiling tiles.

O. 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.

P. Make joints of threaded pipe by cutting pipe square and reaming inside.

Q. Use joint compound sparingly.

R. Install joints for mechanical coupled pipe according to manufacturer's recommendations. Use manufacturer’s gasket lubricant sparingly.

S. Pipe grooving shall be per coupling manufacturer’s instructions.

T. Welded joints shall be made in fabrication shop. No welding allowed at project site.

U. Hangers, Bracing, and Restraint of System Piping:
   1. Provide hangers and associated parts to support piping in perfect alignment without sagging or interference, to permit free expansion and contraction, and meet requirements of NFPA 13 and manufacturer’s installation instructions.
   2. Select and size building attachments per Manufacturer Standardization Society (MSS) standards and manufacturer’s published load rating.
   3. Coordinate hanger support installation to group piping of all trades.
   4. Hang pipe from building members using either concrete inserts for concrete construction or beam clamps for steel construction. Installation shall comply with manufacturer’s installation instructions. Expansion type inserts may be used for branch piping.
   5. Restraining clips/clamps are required in locations where vibration may be a concern. Refer to Section 23 0550 – Vibration Isolation, for additional information regarding restraining clips/clamps.
   6. Suspend hangers by means of electroplated zinc or hot-dipped galvanized finish hanger rods. Perforated band iron and flat wire straps (strap iron) are not allowed.
   7. Mains parallel to joists shall not be supported from a single joist. Mains parallel to joists shall be supported by trapeze hanger and be positioned equally between two joists. Trapeze hangers shall be positioned to load joists at panel points only.
   8. Support pipe from top flange of beams.
   9. Where joists are used, locations of pipe supports shall be approved by the structural engineer prior to installation.
   10. Do not support equipment or piping from metal roof deck.

V. Install flexible fitting at building’s expansion joints per manufacturer’s instructions.

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

3.4 CLEANING

A. Clean systems after installation is complete.

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

C. 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.

3.5 TESTING

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

B. Perform all NFPA required acceptance tests.

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

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

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

F. Log of tests shall be kept at job site and shall identify:
   1. Who performed test
   2. Time of test
   3. Date of test
   4. Section of system tested
   5. Results of test
   6. Completed Contractor's Material and Test Certification form(s) from NFPA 13

G. Operate flow switches to test that signals are transmitted to Fire Alarm Control Panel.

H. Include test for tamper switches.

END OF SECTION

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SECTION 22 0000 GENERAL PLUMBING REQUIREMENTS

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 0529 - Piping and Equipment Supporting Devices

C. Section 20 0553 - Mechanical Systems Identification

D. Section 20 0573 - Mechanical Systems Firestopping

E. Section 20 0700 - Mechanical Systems Insulation

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

END OF SECTION

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SECTION 22 0594 DOMESTIC WATER SYSTEMS BALANCE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 22 1118 – Water Distribution System

B. Section 22 2114 – Plumbing Specialties

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 DESCRIPTION

A. Plumbing Contractor shall be responsible for providing complete testing and balancing work of liquid fluid handling systems, such as domestic hot water return, , water mixing valves, and other processes included in this Project.

B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports as specified herein.

C. Scope of work includes new work specified herein and includes all equipment, distribution systems, and terminal units connected.

D. Scope of work also includes existing liquid fluid handling systems as defined by drawings and/or schedules.

E. Work is limited to new areas within construction boundaries and does not include central pumping equipment or other areas. Adjust and balance flows to values indicated or scheduled. If flow is abnormal, attempt to proportional balance flows to the same percentage below design and contact Engineer for additional instruction.

F. Procedures shall be in accordance with the latest edition of AABC or NEBB and as per detailed herein.

G. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval.

H. Contractors who are members of AABC or NEBB and who have qualified personnel available to perform Work may submit Quality Assurance Submittal for approval. Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor who will submit it for approval.

I. Upon direction of Architect/Engineer or TAB subcontractor, Contractor shall provide (at no additional cost to Owner) any additional work and/or devices necessary to properly balance the system, including calibrated balancing valves, gauge tappings, flow sensors, and thermometer wells. Contractor shall be responsible for trimming and balancing pump impellers as necessary to obtain design pump flow rates at minimum pressure differential.

J. TAB work shall not proceed until all assigned personnel have been approved by, 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 complete before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Engineer.

1.4 SUBMITTALS

A. General:
   1. Make submittals in accordance with Section 01 3300 – Submittals. Submit minimum of 5 copies of all submittals unless otherwise directed.
   2. Reports shall be assembled using a 3-ring hard cover binder with Project Name and location on the cover and the side panel. Information sheets shall be 8-1/2" x 11" white bond paper. Use pre-printed forms of NEBB or AABC wherever possible. Assemble report in the following order.
      a. Transmittal letter
      b. Cover sheet with Project title, location, submittal date, and names and addresses of Owner, 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
      e. Provide numbered tabs for each system.

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 required
         2). Names of 3 recent relevant completed projects along with the project address, Owner's contact person, supervising design professional.
      b. Supervisor resume
      c. Balance technician(s) resume
   2. Architect/Engineer and Owner reserve 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-EXECUTION of this Section to demonstrate to Engineer and Owner that proper procedures are being followed. Planning Report shall be submitted after Quality Assurance submittal and 30 days before 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 A/E 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.

1.5 REFERENCE STANDARDS

A. Refer to the latest publications of the NEBB, the American Society of Plumbing Engineers (ASPE) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) for establishing required procedures.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

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

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

PART 3 - EXECUTION

3.1 GENERAL

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

B. Set point for individual branch balancing valves in domestic hot water return systems shall be 0.5 gpm unless otherwise noted on drawings or schedules.

C. Set point for domestic hot water return circulating pump shall be the flow rate defined in Section 22 1118.

3.2 PLANNING PHASE

A. Procedure:
   1. Obtain latest contract documents including addenda and change orders. Obtain shop drawings and performance curves from Contractor for pumps, flow measuring devices, and terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.

B. Planning Report:
   1. Planning Report shall contain the following minimum requirements.
      a. Narratives:
         1). Provide written narratives of procedures used. Provide separate narratives for each pump and liquid fluid handling system.
         2). Identify flow-measuring devices to be used at each pump and terminal device. Provide different narratives for constant and variable flow systems.
         3). For non-standard water systems, include narratives on how to measure and adjust for different viscosities.
         4). 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. For this Project, minimum acceptable is ± 10% of design flow.

b. Prebalance Checklist: include, but not limited to:
   1). Check for completeness or work
   2). System cleaning
   3). System fill and air venting
   4). Place system into operation
   5). Check expansion tanks and fill pressures
   6). Pump bearings, alignment, starters, vibration isolators, rotation
   7). Setting valves to proper position including shutoff and bypass valves
   8). Set up of controls and control devices

c. Measuring Instrument List: list measuring instruments to be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
   1). Manufacturer name and model number
   2). Measurement range
   3). Pressure/temperature limits
   4). Date put into service
   5). Date of last calibration
   6). Include certificate from calibration firm

2. 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 the past year.
3. Samples: Submit copies of TAB forms to be used.
4. Branch circuit and terminal measurements: indicate on pre-printed forms of AABC or NEBB measurements to be taken in the field. Include branch circuit or terminal identification, system, space served, location, design flows (include zone and system summaries), and flow measuring device size, type, Cv, and manufacturer. Indicate initial setpoint on forms.

3.3 SET-UP PHASE

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

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

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

3.4 FINAL BALANCE PHASE

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

B. Final Report:
   1. Submit report to Engineer and to Contractor indicating 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 the design tolerance of ± 10% of design flow. Contractor shall resubmit all or portions of Final Report as directed by Engineer.

END OF SECTION

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SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to Section 019100.

C. Commissioning requires the participation of the Division 22 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019100. Division 22 Contractor shall be familiar with all parts of Section 019100 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of Section 019100.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 019100 - Commissioning
2. Section 230800 - Commissioning of HVAC
3. Section 260800 - Commissioning of Electrical
4. Section 270800 - Commissioning of Communications

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.
2. Infrared thermometer gun.
3. Analog differential pressure gauge and associated tubing.
4. Portable computer with access to the building automation system.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°°F and a resolution of +/- 0.1°°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 019100 for additional Division 22 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of Section 019100.

END OF SECTION - 220800

SECTION 22 1118 WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers interior domestic cold water, domestic hot water and domestic hot water return.

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 0529 - Piping and Equipment Supporting Devices

B. Section 20 0553 - Mechanical Systems Identification

C. Section 20 0700 - Mechanical Systems Insulation

D. Section 22 0594 - Domestic Water Systems Balance

E. Section 22 2114 - Plumbing Specialties

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 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.

1.5 DELIVERY, STORAGE, AND HANDLING

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

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

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

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

E. Before shipping, piping shall be cleaned, free of rust and scale, and chemically treated to protect inside of pipe from rusting, and furnished with end caps.

1.6 SUBMITTALS

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

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
      e. Exposed tubing and fittings in kitchen and areas subject to chemical cleaning shall have chrome plated finish.
   2. Copper (3" and larger):
      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: Brazed, BCuP-3 or BCuP-5 type, AWS A5.8, 1250°F minimum melting point

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 - General:

1). Basis of design - Milwaukee

2). All valves shall have threaded ends.

B. Ball Valves:

3). Basis of design - Milwaukee

4). Acceptable manufacturers: Apollo, Crane, Hammond, Jomar, Milwaukee, Stockham and Watts with indicated features and equal to model listed. Note that not all manufacturers make all sizes.

a). Full Port, 2 Piece: Bronze body, ASTM B584, stainless steel ball, teflon seats, stem extension, 600 psi WOG pressure rating, threaded ends, Apollo Series 77-900, Hammond Series 8303, Jomar T100.

b). Insulated Handle: For insulated systems to prevent condensation on valve body with thermal and vapor seal, equal to Nibco Nib Seal.

5). Butterfly Valves:

a). Basis of design - Milwaukee

b). Acceptable Manufacturers: Crane, Hammond, Milwaukee and Stockham with indicated features and equal to model listed. Note that not all manufacturers make all sizes or styles.

c). Threaded: Bronze body, stainless steel disc and stem, viton disk seal, Milwaukee Series BB2.

d). Lug Type: Ductile iron body, aluminum bronze disc, EPDM liner, 316 stainless steel stem, brass bushings (lower, upper and collar), 200 psi WOG pressure rating, lever handle through 6", gear operator 8" and larger, Crane Quartermaster 44-B-S-Z.

e). Wafer Type: Ductile iron body, aluminum bronze disc, EPDM liner, 316 stainless steel stem, brass bushings (lower, upper and collar), 200 psi WOG pressure rating, lever handle through 6", gear operator 8" and larger, Crane Quartermaster 42-B-S-Z.

C. Check Valves:

1. Basis of design - Nibco

2. Size 3" and Smaller:

a. Bronze body, ASTM B62, Y pattern, Buna-N resilient disc, horizontal swing, 200 psi WOG rating, Nibco, Stockham, Milwaukee.

3. Valves 4" and Larger:

a. Iron body, horizontal swing, cast bronze disc and seat, 200 psi WOG rating, Nibco, Stockham, Milwaukee.

4. Size 1/2" thru 2":

a. Stainless steel body, in-line pattern, stainless steel seats, spring and valve disc. Durabla Basic Check, Model BSS, rated for 300 psi WSP.

b. Manufacturers: Nibco, Watts, Mission, Durabla, Circle Seal, Milwaukee, Stockham.

D. Balancing Valves:

1. Acceptable Manufacturers: Nibco or Tour and Anderson, or approved equal prior to bid.

2. Variable orifice with multiple turn valve type, bronze or brass body, soldered connections, 125 psig WP or 400 psi WOG at maximum temperature of 250°F. Furnish valve with quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index, and memory locking device to limit return of valves to preset open position after shut-off.

E. Mixing Valves:

1. TMV-1 Thermostatic Point of Use Tempered Water Mixing Valve
   a. Basis of design - Guardian
   b. Acceptable manufacturers: Lawler, Leonard, Powers, Guardian, Chicago Faucets or approved equal.
   c. Master emergency fixture thermostatic mixing valve, capable of maintaining mixed water temperature within 2 degrees F of setpoint.
   d. Mixing valve shall be bronze construction with thermostatic element, high temperature limit stop, locked temperature regulator and integral thermometer on mixed water line. Valve shall be rated for 125 psig operating pressure and be ASSE 1070 certified and labeled

2.5 DIELECTRIC FITTINGS

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

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

2.6 WATER HAMMER ARRESTORS

A. Mechanical Water Hammer Arrestors:

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

2.7 EXPANSION JOINTS/LOOPS

A. Copper Piping:

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

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

B. Copper Piping:

1. Mechanical expansion fittings, size 3/4" thru 4", copper tube sweat ends, stainless steel laminated internal bellows, 200 psig working pressure, 600°F rated; Keflex Model 7QT.

2. Mechanical expansion fittings, sizes 3/4" thru 4", copper tube sweat ends, stainless steel laminated internal bellows, 175 psi working pressure, 500°F rated, Hyspan Model 8509 or 8510.

3. Allowable length of copper tube per mechanical expansion fitting shall be in accordance with the following table:

System Operating Temperature	Length of Pipe
110°F	300 ft
120°F	275 ft
130°F	250 ft
140°F	225 ft
150°F	175 ft
160°F	175 ft
170°F	150 ft
180°F	140 ft

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

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 protective sleeve covering of elastomeric pipe insulation where copper or steel piping is embedded in masonry or concrete.

I. Provide dielectric fittings between dissimilar piping materials.

J. 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.

K. 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.

L. Install water pipe using proper pipe and fittings. Use reducing fittings for changes in pipe size.

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

D. 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 elasomeric 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 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.

3.4 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.

3.5 EXPANSION JOINTS

A. Install one anchor on either side of expansion joint, opposite direction of expansion.

B. Install pipe guides on each side of mechanical expansion fittings.

3.6 VALVE ACTUATORS

A. Install chain operators on ball, gate and butterfly valves (2-1/2” and larger).

B. Provide electric valve actuator and related accessories, compatible with valve specified. Coordinate valve actuation requirements and connection of actuation source to valve with Division 26 Contractor.

3.7 CLEANING

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

B. Remove, clean, and reinstall all strainers and faucet aerators after flushing and cleaning of domestic water systems is complete.

3.8 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 150 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.

3.9 BALANCING

A. Balance water distribution system. Adjust control valves for proper operation. Set balancing valves to maintain hot water in hot water system.

B. Balance flush valves, flow control valves and mixing valves for adequate flow and temperature to plumbing fixtures and equipment.

3.10 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.

3.11 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 1314 SANITARY WASTE AND STORM DRAINAGE SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes materials and methods for sanitary waste and vent, clearwater waste and vent, storm drainage, and overflow storm drainage piping systems.

1.2 RELATED WORK

A. Section 20 0529 - Piping and Equipment Supporting Devices

B. Section 20 0700 - Mechanical Systems Insulation

C. Section 22 2114 - Plumbing Specialties

D. Section 22 4000 - Plumbing Fixtures

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. Air gap fittings
6. Traps

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 PIPE, FITTINGS, AND JOINTS

A. Interior Above Ground:
   1. Cast Iron:
      a. Pipe: Hubless cast iron pipe, ASTM A-888, CISPI 301.
      b. Fittings: Hubless cast iron fittings, ASTM A-888, CISPI 301.
      c. Joints:
         1). Heavyweight Couplings: No-hub couplings with 0.060" thick stainless steel clamps, FM 1680 Class 1, ASTM Standard C-1540 Mission Heavyweight, Husky Series 4000 or Clamp-All Hi-Torq 125.
   2. Copper:
      a. Pipe: Type DWV copper tube, ASTM B306.
      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.

2.3 CLEANOUTS

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

B. Provide recessed, solid brass, cleanout plugs where fittings are used as cleanouts. Provide taper-thread plug with Teflon tape thread wrap.

C. Floor Cleanouts: Cleanout with cast iron ferrule, adjustable top, nickel-bronze scoriated cover and frame, bronze taper-thread plug, equal to J.R. Smith 4033L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4033L-F-C.

D. Floor Cleanouts, Carpeted Areas: Cleanout with cast iron ferrule, adjustable round top, nickel-bronze scoriated cover and frame, bronze taper-thread plug, and small stainless steel carpet marker, equal to J.R. Smith 4033L-Y. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4033L-F-C-Y.

E. Floor Cleanouts, Tiled Areas: Cleanout with cast iron ferrule, adjustable square tile top, nickel-bronze scoriated cover and frame, and bronze taper-thread plug, equal to J.R. Smith 4053L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4053L-F-C.

F. Floor Cleanouts, Unfinished Floors and Areas Outside Building: Cleanout with cast iron ferrule, adjustable round top, scoriated cast iron tractor cover, and bronze taper-thread plug, equal to J.R. Smith 4239L. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4239L-F-C.

G. Floor Cleanouts, Areas with Heavy Traffic: Cleanout with cast iron ferrule, adjustable housing, heavy-duty ductile iron scuriated top, and brass taper-thread plug, equal to J.R. Smith 4233L-M. Provide flashing flange and clamp where cleanout is installed in elevated slabs, equal to J.R. Smith 4233L-M-F-C

H. Wall Cleanouts: Cleanout with cast iron counter sunk ferrule, bronze or brass taper-thread plug, secured stainless steel access cover, equal to J.R. Smith 4472T.

2.4 FLOOR DRAINS

A. Josam, Smith, Wade or Zurn, equal to number listed in Drains 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.

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

D. 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.

E. FD-1: Cast iron body with round diameter satin nickel bronze strainer. Where indicated on drawings. J.R. Smith 2005Y-A.

2.5 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.

2.6 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.

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 1/4" per foot, except piping 4" diameter or larger which may be run at 1/8" per foot slope with approval of the local authority.

D. 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.

E. 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 feet away from any 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.

F. 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.

G. Provide protective sleeve covering of elastomeric pipe insulation, where piping and/or fittings are embedded in masonry or concrete.

H. Maintain piping in clean condition internally during construction.

I. Mitered ells, notched tees, and orange peel reducers are not allowed. Bushings are not allowed on threaded piping.

J. 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.

K. Set cleanouts true and level and protect properly throughout construction. Provide safing for cleanouts installed in elevated slabs.

L. 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.

M. 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 the 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.

N. 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 COPPER PIPE

A. Remove slivers and burrs remaining from cutting operation by reaming and filling both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from cleaning operation, apply approved, non-acidic flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joining. Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

3.3 CAST IRON PIPE

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

B. Install cast iron pipe and fittings as recommended by CISPI in their publication "Installation of Cast Iron Soil Pipe and Fittings".

C. Support piping at every coupling. Locate hanger within 18 inches of the coupling.

D. Installations with multiple joints within a four-foot developed length shall be supported at every second joint.

E. Secure the base of risers with thrust restraints to prevent joint separation. Restraint shall be in accordance with CISPI recommendations.

F. Brace horizontal piping 5 inch and larger to prevent horizontal movement. Install bracing at every branch connection and every change of direction in accordance with CISPI recommendations.

3.4 TESTING

A. Refer to Testing paragraph of Section 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

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SECTION 22 2114 PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section covers material specialties for piping systems.

B. All components installed on water systems defined in Section 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 0594 - Domestic Water Systems Balance

B. Section 22 1118 - Water Distribution System

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

A. Manufacturer's technical data for the following:
   1. Strainers
   2. Trap primers
   3. Backflow preventers
   4. Flexible connections
   5. Air vents
   6. In-line check valves
   7. 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 STRAINERS

A. 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.

2.3 BACKFLOW PREVENTER

A. Reduced Pressure Zone Backflow Preventers:
   1. Manufacturers: Cla-Val, Febco, Apollo or Watts, equal to model listed
   2. 3/4" through 2": Lead free cast copper silicon body, resilient check valve seats, shut-off valves, 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

2.4 TRAP PRIMERS

A. Manufacturers: Precision Plumbing Products, Portland, OR.

B. Trap primer consist of: a sub-miniature solenoid valve, an electronic timer, a physical air gap and a 6' electrical cord (three prongs plug only provided with SMP -500-115V). By incorporating is capable of priming up to four floor drain traps. Model SMP-500-115V.

C. When the timer energizes the solenoid valve discharges potable water across the air gap funnel for a set amount of time, and when the timer deactivates the solenoid valve closes.

D. Approximately 2 ounces of water at 20 PSIG is discharges in a 24-hour cycle. Solenoid valve on inlet to be controlled by local timer. Timer to operate on 120 V 6'-0" power cord.

E. Precision Plumbing Products – Model SMP-500-115V.

2.5 IN-LINE CHECK VALVES

A. Manufacturers: Circle Seal Control, DFT, Inc., Apollo Division - Conbraco Industries,

B. Bronze or bronze/stainless steel construction with spring loaded check (316 stainless steel spring) and straight through flow. Apollo Ball-Cone model 62-100 Series, or approved equal.

2.6 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.

2.7 SAFINGS

A. 4 lb/ft^2 sheet lead, to 18" beyond edge of drain on all sides.

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

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. 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.

B. Install strainers for equipment including pumps, meters, backflow preventers, reducers and regulators, and as shown on drawings.

C. Install in-line check valves where specified or as indicated on drawings.

D. Install flexible connections for base mounted pumps and other vibrating equipment.

E. Safing:
   1. Install safing for floor drains. Extend safing to 18" from edge of drain. Safing shall be clamped to floor drain body and pitched to drain to weep holes. Floor drains installed in unexcavated areas do not require safing.
   2. Where core drilled floor drain installation into existing floor slab has been approved by A/E, drain strainer inlet shall be grouted in place with non-shrink epoxy concrete approved by Structural Engineer.

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 4000 PLUMBING FIXTURES

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 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 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 or molded "stone" inert base and plasticizer. 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. Flush Valves: Sloan or Zurn equal to number listed

D. Stainless Steel Sinks: Elkay or Just equal to number listed

E. Scrub Sinks: Kohlor, Amercian Standard, or Zurn euql to model listed.

F. Electric Water Coolers: Elkay, Halsey-Taylor, Oasis, or Sunroc equal to model listed

G. Service Sinks: American Standard, Eljer, or Kohler equal to number listed

H. Mop Basins (Janitor Sinks): Fiat, Mustee, Stern-Williams, equal to number listed

I. Emergency Eyewashes and Showers: Bradley, Guardian, Haws, equal to number listed

J. Manual Faucets: Chicago Faucet, T and S Brass, or Zurn equal to number listed

K. Sensor Activated Faucets: Chicago Faucet, Sloan, or Zurn equal to model listed

L. Fixture Traps: Engineered Brass Company, Kohler, McGuire, or Zurn equal to number listed

M. Insulated Traps and Supplies: McGuire, ProFlo, or True-Bro equal to model listed

N. Supplies and Stops: Chicago Faucet, Kohler, McGuire or Zurn equal to number listed

O. Supplies and Stops: Brasscraft, Engineered Brass Company, Kohler, LSP Aqua-Flo or McGuire equal to number listed

P. Shower Valves and Mixing Valves: Leonard, Powers, or Symmons equal to number listed

Q. Washer Boxes: IPS Corp. or equal to model 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 (standard height, public and staff toilet rooms)

1. Fixture: American Standard "Millennium" Model 2633.101, white vitreous china, wall hung siphon jet, elongated bowl, 1.6 gallon per flush, 1 ½" top inlet spud.

2. Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.

3. Flush Valve: Sloan Royal #111-SMO, exposed diaphragm type flushometer, side mount sensor operated, top spud connection, 1.6 gallons per flush.

4. Seat: Bemis #1955-SS/C, heavy duty, elongated bowl, open front, plastic seat, less cover, white color, with stainless steel self-sustaining check hinge.

5. Carrier: J.R. Smith, series 210Y-M54-XH extra heavy, or similar bariatric rated, Josam, Zurn.

B. WC-2 Water Closet (wall-hung, barrier-free, public and staff toilet rooms)

1. Same fixture and fittings as WC-1.

2. Provide carrier support for barrier free mounting height of minimum 18" to top of bowl from finished floor.

C. WC-3 Water Closet (wall-hung, with bed pan washer, patient toilet rooms)

1.Fixture: American Standard "Millennium" Model 2633.101, white vitreous china, wall hung siphon jet, elongated bowl, 1.6 gallons per flush, bedpan lugs, 1-1/2" top inlet spud.

2.Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.

3.Flush Valve: Sloan Royal BPW-1150-1.6, exposed diaphragm type flushometer with bedpan washer, side oscillating handle, top spud connection, 1.6 gallons per flush, diverter valve assembly with spray arm.

4.Seat: Bemis 1955-SS/C, heavy duty, elongated bowl, open front, plastic seat, less cover, white color, with stainless steel self-sustaining check hinge.

5.Carrier:

a. J.R. Smith, series 210Y-M54-XH extra heavy or similar, Josam, Zurn.

6.Provide carrier support for barrier free mounting height of 18" to top of bowl from finished floor.

2.5 URINALS

A. UR-1 Urinal (wall-hung)

1.Fixture: American Standard Jetbrook #6571.011, white vitreous china, wall mounted blowout type, rim extended to 20-3/4" from wall, 1-1/4" top inlet spud.

2.Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.

3.Flush Valve: Sloan Model 186-1.0SMO battery operated, side mount flushometer.

4.Carrier: Josam, J.R. Smith, Zurn rectangular uprights, bearing plate.

B. UR-2 (wall hung, barrier-free)

1. Same fixture and fittings as UR-1.
2. Provide carrier support for barrier-free mounting height of maximum 17” to top of rim from finished floor.

2.6 LAVATORIES

A. L-1 Lavatory (wall-hung, barrier Free)

1.Fixture: Kohler “Greenwich” K-2031-R, 20” x 18”, vitreous china, wall hung, 2 faucet holes, drilled for carrier support, mount at 34” above finished floor to rim.

2.Faucet: T and S Brass B-2866-05-LF15, swivel gooseneck spout with non-aerating 1.5 GPM, laminar flow outlet, and wrist-blade handles.

3.Drain: Kohler K-7715(*), McGuire 155A(*), grid drain, 1-1/4” tail piece.

4.Trap: Kohler K-8999(*), McGuire B8902(*), 1-1/4” x 1-1/2” cast brass P-trap with cleanout, 17 ga tubing outlet.

5.Stops and Supplies: Chicago Faucet 1017-CP, Kohler K-7601-P, McGuire HST02CP, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, ½” soldered inlet x 3/8” compression outlet.

6.Carrier: Josam 17100/17105, J.R. Smith 700-M31, Zurn Z-1231, concealed arms, rectangular steel uprights.

7.Shroud: True Bro Lav Shield Model #2018-KO-G.

B. L-2 Lavatory (Integral - round).

1. Fixture: One piece solid surface countertop and bowl supplied by trade contractor. 2 faucet holes. Refer to architectural details for size and configuration information.

2. Faucet: Chicago Faucet “Hy Tronic” Model 116.431.AB.1 senor operated gooseneck faucet with dual supply for hot and cold water and internal mixer. Laminar flow. No aerator.

3. Drain: Kohler K-7715, McGuire 155A, grid drain, 1-1/4” tailpiece.

Trap: Kohler K-8999, McGuire B8902, 1-1/4” x 1-1/2” cast brass P-trap with cleanout, 17ga tubing outlet.

4. Stops and Supplies: Chicago Faucet 1017-CP, Kohler K-7601-P, McGuire HST02CP, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems and gland nuts, ½" soldered inlet x 3/8" compression outlet.

C. L-3 Lavatory (Integral - round)

1.Fixture: One-piece solid surface countertop and bowl supplied by trade contractor. 2 faucet holes. Refer to architectural details for size and configuration information 2.FaucetT and S Brass B-2866-05-lf15, swivel gooseneck spout with non-aerating 1.5 gpm, laminar flow outlet, and wrist blade handles.

3.Drain: Kohler K-7715(*), McGuire 155A(*), grid drain, 1-1/4" tail piece.

4.Trap: Kohler K-8999(*), McGuire B8902(*), 1-1/4" x 1-1/2" cast brass P-trap with cleanout, 17 ga tubing outlet.

5.Stops and Supplies: Chicago Faucet 1017-CP, Kohler K-7601-P, McGuire HST02CP, angle pattern, lock shield cap, loose key handle, with copper alloy control valve bodies, stems, and gland nuts, ½" soldered inlet x 3/8" compression outlet.

6.Furnish and install True Bro ADA trap wrap on piping and valves if exposed under counter.

2.7 SINKS

A. S-1 Sink (counter mounted, single bowl)

1. Fixture: Elkay "Lustertone" #LRAD-2219, type 302 stainless steel, 18 ga, self-rimming, single compartment, satin finish, fully undercoated, compartment dimensions 18" x 14" x 6" deep, 3 faucet holes
2. Faucet: T and S Brass #B-2866-05-LF15, with non-aerating faucet, 8" swing gooseneck, wrist blade handles, 1.5 gpm laminar flow, 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
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" soldered inlet x 1/2" compression outlet

B. S-2 Sink (counter mounted, double bowl)

1. Fixture: Elkay "Lustertone" #LRAD-3322, Type 302 stainless steel, 18 ga, self-rimming, double compartment, satin finish, fully undercoated, each compartment dimension 13.5" x 16" x 6" deep, 3 faucet holes
2. Faucet: Chicago Faucet #201-AGN8AE35-317AB, mixing valve faucet,8" swing gooseneck, wrist blade 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" soldered inlet x 1/2" compression outlet
6. Hot Water Dispenser: Insinkerator #H-770, undersink mounted hot water dispenser, 1/2 gal capacity insulated tank with drain plug, chrome plated faucet, adjustable thermostat, capacity of up to 60 cups per hour of 180°F water, self-closing valve, and 1 yr parts and service warranty. Electrical: 750 watts, 6.5 amps, 120 V

7. Disposer: Insinkerator #777, garbage disposer, all stainless steel, auto reversing action, manual reset, and 5 yrs parts and service warranty. Electrical: 3/4 hp, 120 V, 1 Ph, 7.6 amps, all stainless steel

C. S-3 Sink (wall hung, single bowl)

1. Fixture: Elkay #ELV2219, type 304 stainless steel, 18 ga, self-rimming, single compartment, satin finish, fully undercoated, compartment dimensions 16" x 11.5" x 5.5" deep, 1 faucet hole
2. Faucet: Chicago Faucet" HyTronic" Model 116.431. AB.1 sensor operated gooseneck faucet with dual supply for hot and cold water and internal mixer. Laminar flow outlet. No aerator.
3. Drain: Elkay #LK-99 1-1/2" diameter drain with conical strainer basket, stainless steel construction
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" soldered inlet x 1/2" compression outlet
6. Furnish and install True Bro ADA trap wrap on exposed piping, valves, etc. under sink.

D. S-4 Sink (double compartment, counter unit)

1. Fixture: Elkay SSP, LLC #2C18X18-2-18X, type 304 stainless steel, 16 ga,, double compartment with left and right drainboards, 10" backsplash, satin finish, fully undercoated, compartment dimensions 18" x 18" x 12" deep, 3 faucet holes, 8" centers.
2. Faucet: Chicago Faucet #510-G613L12XKCAB faucet with dual supply for hot and cold water and spray hose integral, wall mounted includes bracket for spray hose.
3. Drain: Elkay #LK-99 1-1/2" diameter drain with conical strainer basket, stainless steel construction
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" soldered inlet x 1/2" compression outlet

6. **SCRUB SINKS**

A. SS-1 Scrub Sink (single station)

1. Fixture: single compartment scrub sink supplied by owner.
2. Faucet: Supplied by owner
3. Drain: Kohler K-9115.
4. Trap: Kohler K-9000 17 ga cast brass, chrome plated, 1-1/2".

B. SS-2 Scrub Sink (single station)

1. Fixture: Kohler "Hollister" k-12793-0 single compartment scrub sink.
2. Faucet: Chicago Faucet "HyTronic" Model 116.431.AB.1 sensor operated gooseneck faucet with dual supply for hot and cold water and internal mixer. Laminar flow outlet. No aerator.
3. Drain: Kohler K-9115.
4. Trap: Kohler K-9000 17 ga cast brass, chrome plated, 1-1/2"

2.8 CLINICAL SERVICE SINKS

A. A. CS-1 Clinical Service Sink (wall-mounted)

1.Fixture: Kohler #K-12867, "Camerton", white vitreous china, flushing rim, blowout action, wall hung, 1-1/2" top spud connection, drilled for carrier support.

2.Flush Valve: Sloan S3080553, exposed diaphragm type flushometer, side oscillating handle, top spud connection, 6.5 gallons per flush.

3.Faucet: Chicago Faucet #814-VB-245 flush valve pipe brace, vacuum breaker, 6 inch wrist blades, ¾" hose thread outlet, integral stops.

4.Pedal Valve: Chicago Faucet #910G-777-19K wall mounted pedal valve, elevated vacuum breaker, spray head and 4-foot hose.

5.Fixture Fittings and Accessories: Gaskets-wax, bolts with chromium plated caps, nuts, and washers.

6.Carrier: Josam, J.R. Smith, or Zurn Rectangular steel uprights.

2.9 SHOWERS

A. SH-1 Shower

1. Floor and Enclosure by General Contractor. (36" x 36")
2. Valve: Symmons Temptrol Model #96-300-B30-V-X-72 pressure balancing mixing valve with lever handle, integral service stops and adjustable stop screw to limit handle turn. Wall/hand shower with 6 ft flexible metal hose, in-line vacuum breaker. 30" slide bar for hand shower mounting. Include stainless steel grab bar, fold up seat, shower curtain rod and hooks. See architect spec for rod and hooks.
3. 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.

2.10 ELECTRIC WATER COOLERS/DRINKING FOUNTAINS

A. EWC-1 Dual Electric Water Cooler with Bottle Filling Station:

1.Fixture: Elkay Model #LZSTL8WSLP, bottle filling station, bi-level ADA cooler with hands free, visual filter monitor, automatic filter status reset, filtered, energy savings, laminar flow, antimicrobial, real drain. Water cooler, wall hung, stainless steel basin, and with flow restricting bubbler.

2.Trap: Kohler K-9000, 1-1/4" w/cleanout.

3.Supply/Stop: McGuire, 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.

2.11 JANITOR'S SINKS

A. JS-1 Janitor's Sink:

1. Fixture: Fiat #MSB-2424 stain resistant, molded stone 24" x 24" x 10" mop basin, white, and integral stainless steel drain body
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 #MSG2424. Stainless steel wall guards on two walls, Type 304, 20 ga, and 12" high.

2.12 HOSE BIBB

A. HB-1 Wall Faucet

1. Fixture: Woodford Model 24P, or approved equal, polished chrome, 3/4" inlet with metal wheel handle and Nidel Model 34HF vacuum breaker.

2.13 WALL HYDRANTS

A. WH-1 Wall Hydrant (Recessed, in public toilet rooms):
   1. Fixture: Woodford Model B24, chrome box and door, back-flow protected, with loose key operator

2.14 EMERGENCY SHOWER AND EYEWASHES

A. EW-1 Emergency Eyewash (Wall-mounted):
   1. Fixture: Bradley #S19274HW wall mounted, vertical swing, stainless steel spray heads with dual automatic pressure compensation devices, stay-open brass ball valve, and meets requirements of ADA

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.

H. Install flush valves for barrier-free water closets with operator handle facing wide side of toilet stall.

I. Provide unions at water connections to drinking fountains and electric water coolers.

3.2 PROTECTION

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

3.3 CLEANING

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

END OF SECTION

SECTION 22 4014 EQUIPMENT BY OTHERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Items specified herein shall be provided by Plumbing Contractor to make equipment provided by others and Owner functional.

1.2 RELATED WORK

A. Section 22 1118 - Water Distribution System

B. Section 22 1314 - Sanitary Waste and Vent System

C. Section 22 2114 - Plumbing Specialties

1.3 REFERENCE

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

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

2.2 OWNER FURNISHED EQUIPMENT

A. Where utility services are required for equipment connection, provide the following:
   1. Pressure relief device between isolation valve and quick connect on pressurized gas services; Ross L-O-X Series 15.

2.3 ICE MACHINE (EQ-IM-X)

A. Provide isolation valve on domestic water supply. Refer to Section 22 1118 for specific information.

B. Provide water hammer arrestor on domestic water supply. Refer to Section 22 1118 for specific information.

C. Provide dual check backflow preventer on domestic water supply. Refer to Section 22 2114 for specific information.

D. Provide water filter on water supply. Filter shall have (2) 0.5 micron filter cartridges piped in parallel, inlet and outlet lead free isolation valves, flush kit, and inlet and outlet pressure gauges. Filter shall be Watts QTCBMX-2L-.5M or approved equal.

E. Provide indirect waste pipe from ice machine to local drain. Refer to Section 22 1314 for specific information.

EXECUTION

2.4 INSTALLATION

A. Plumbing Contractor shall install items specified herein as recommended by respective manufacturers. Final connections of waste, water, air, gas, etc., shall be installed by Plumbing Contractor as directed by equipment manufacturer. Incidental items, such as, adapters and unions required to make final connection shall be provided by Plumbing Contractor.

B. Coordinate rough-in sizes and elevations with equipment supplier before proceeding with work.

END OF SECTION

SECTION 22 6316 MEDICAL GAS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Furnish and install a complete piped and wired Level 1 medical gas system including all piping fittings, valves, valve boxes, alarms and pressure switches, hardware and wiring.

B. Systems included are oxygen, medical air, medical-surgical vacuum, waste anesthetic gas disposal (WAGD), nitrous oxide, nitrogen, carbon dioxide. and instrument air.

1.2 RELATED WORK

A. Section 20 0529 - Piping and Equipment Supporting Devices

B. Section 20 0553 - Mechanical Systems Identification

C. Section 20 0573 - Mechanical Systems Firestopping

D. Section 22 2114 - Plumbing Specialties

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.

B. Equipment and installation shall be in accordance with NFPA 99, Healthcare Facilities, 2005 Edition.

C. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 SUBMITTALS

A. Provide manufacturer's product data for the following:
   1. Pipe, fittings and joints.
   2. Shutoff valves.
   3. Valve-in-boxes.
   4. Alarm system including components and accessories.
   5. Terminal units.

B. Brazing Procedures Specification

C. Certificate of Compliance regarding medical gas system installation and connections

D. Provide manufacturer's warranties as identified in this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be new unless otherwise noted.

B. Material designated to be "Oxygen Clean" shall be purchased as "Oxygen Clean" and delivered to project site in the original packaging. This material shall be stored in fashion to remain "Oxygen Clean".

C. Contractor is not allowed to clean "Oxygen Clean" material which has become contaminated except as allowed in this Specification.

2.2 MANUFACTURERS

A. Medical gas outlets, zone valve boxes and valves shall be Chemetron, BeaconMedaes or Amico, equal to items listed. These components shall be provided by single manufacturer.

B. Basis of design - Chemetron.

2.3 PIPE, FITTINGS AND JOINTS

A. Brazed Systems
   1. Pipe:
      a. Copper tube, Type L hard temper, ASTM B819
      b. Pipe shall be oxygen cleaned and capped
      c. Pipe shall be marked "OXY", "MED", "OXY/MED"
   2. Fittings:
      a. Wrought copper fittings, ANSI B16.22
      b. Brazing fitting, MSS SP-73
   3. Joints:
      a. Phosphor, Bronze, Silver (1250-1300°F)
      b. Silver solder NO. 122 or other brazing alloy of equivalent melting point (1145°F) and physical properties.
      c. Solder impurities shall not exceed 0.15%.

B. Soldered Systems
   1. Pipe:
      a. Copper tube, seamless, Type L, hard temper, ASTM B88
      b. Copper tube, Type L hard temper, ASTM B819
   2. Fittings: Wrought copper fittings, ANSI B16.22
   3. Joints: Solder joint, 95-5 tin-silver or tin-antimony solder, or Bridgit lead-free solder

2.4 SHUTOFF VALVES

A. Shutoff valves shall be quarter turn ball type with bronze body, 3-piece design, chrome plated brass ball, full port, double seal, Teflon seats, blowout proof stem, 400 psi WOG pressure rated or vacuum service to 29" Hg rated. Valves shall be furnished with 6" tube extensions on each side of valve. Handle shall indicate open/close position.

2.5 ZONE VALVE BOX (ZVB)

A. Valves shall be equal to shutoff valves specified herein.

B. Valves shall include pressure gauge on the discharge side of valve.

C. Boxes shall be 18 ga steel with white epoxy, lacquer or baked white enamel finish with anodized aluminum trim frame. Trim frame shall allow for 1" plaster adjustment. Flexible window front panel shall be able to be removed in an emergency and easily replaced, lettering shall say, "Caution - Medical Gas Shut-off Valves - Close Only in Emergency".

2.6 ALARMS

A. Basis of design for the medical alarm system is BeaconMedaes MEGA 3 System.

B. Electrical components and wiring must be in conformance with Division 26.

C. Area Alarm Panels (AAP):

1. Area alarms shall be line monitoring closed circuit, self-monitoring with light and pressure gauge. Also included should be green light indicating everything as normal, red light for alarm, audible alarm that can be silenced without shutting off alarm light and test button to check functions of panel.
2. Assembly shall be steel rough-in box with adjustable frame and aluminum front panel.
3. Area alarm panels for medical gases shall indicate if pressure in the lines in the area being monitored increases or decreases by 20% from normal line pressure.
4. Area alarm panels for medical-surgical vacuum shall indicate if vacuum level in the area being monitored drops to or below 12" Hg.
5. Sensors shall be located per Medical Gas Area Alarm Panel Schedule on drawings.

D. Miscellaneous Equipment:

1. Pressure switches shall be gas specific, UL listed, and cleaned for oxygen service.
2. Vacuum switches shall be UL listed and reset automatically when pipeline vacuum returns to normal operating vacuum.

2.7 STATION OUTLET/INLETS

A. Quick Connect:

1. Quick connect medical gas outlets shall be safety keyed with primary and secondary check valves (except vacuum).
2. Rough-in assembly shall be gas specific with steel mounting plate designed to permit ganging of multiple outlets.
3. Finish assembly shall be keyed to only match with appropriate rough-in gas assembly.
4. Station outlet/inlet pattern shall be Chemetron to match existing devices.

B. Threaded:

1. Threaded outlet/inlets shall be non-interchangeable based upon gas service.
2. Outlets shall comply with CGA Standard V-5.

2.8 MEDICAL AIR COMPRESSORS

A. Basis of design for medical air compressor system is BeaconMedaes Series SAS Scroll Type.

B. Medical air compressor system shall be an NFPA 99 compliant system with capacity as indicated on drawings.

C. Connection to medical air compressor package shall be limited to single point 480 V, 3 Ph electrical feed, single air inlet before the inlet filters/silencers, and single air outlet after source shutoff valve. If modular unit is provided, Contractor shall provide piping and accessories required for interconnection of modules.

D. Medical air compressor package shall include the following:

1. Receiver: ASME Section VII rated pressure vessel with safety relief valve, automatic drain, sight glass, pressure gauge and three valve bypass.
2. Dryers: Twin-tower heat-less desiccant dryer for each compressor to provide 10°F pressure dewpoint air. Each dryer shall be sized for peak calculated demand. Duplex refrigerated dryers may be used.
3. Filters: The first stage of filtration shall include high efficiency coalescing prefilters rated at 0.01 micron with automatic drain and element change indicators installed upstream of dryer. The second stage shall include 1 micron particle filters with element change indicator downstream of dryer. Outlet filter shall be sized for 100% of peak calculated demand and shall be rated for minimum of 98% removal of particles 1 micron or greater.
4. Regulators: Duplex regulators with valves to isolate either regulator. Regulators shall be set at 55 psig. Each regulator shall be sized for 100% of system capacity.
5. Dewpoint Monitor: Single dewpoint monitor providing continuous line monitoring with alarm setpoint of 32°F pressure dewpoint.
6. Carbon Monoxide Monitor: Single carbon monoxide monitor providing continuous line monitoring with alarm setpoint of 10 ppm.
7. Other components: Inlet filters/silencers; source shutoff valve; isolation, check and relief valves for each compressor; main relief valve between pressure regulator and source shutoff valve; and interconnecting piping and wiring.
8. Controller: Controller shall include programmable logic controller and provide the following:
    a. NEMA 12 enclosure
    b. Circuit breaker disconnects for each motor with external operators.
    c. Magnetic motor starters for each motor
    d. Pressure control switches
    e. Hand-off-automatic (H-O-A) selector switch
    f. Automatic lead/lag sequencing and automatic alternation of all compressors based on first-on/first-off principle with provisions for simultaneous operation, and reserve unit if required.
    g. Run time hour meters
    h. Visual/Audible alarm indicators for all standard remote alarms
    i. Ethernet connectivity for remote monitoring

E. Vibration Isolation: Refer to Section 23 0550 - Vibration Isolation.

2.9 MEDICAL VACUUM PUMPS

A. Basis of design for medical vacuum system is BeaconMedaes Series VHS.

B. Medical vacuum system shall be oil-less claw type NFPA 99 compliant and shall have capacity as indicated on drawings.

C. Connections to medical vacuum pump package shall be limited to single point **[208] [240] [480]** V, 3 Ph electrical feed, single air inlet from the distribution system and single air outlet to medical vacuum exhaust piping.

D. Medical vacuum pump package shall include the following:
   1. Receiver: ASME rated vessel with drain and three valve bypass.
   2. Other components: Isolation, check and bleed valves for each vacuum pump and interconnecting piping and wiring.
   3. Controller: Controller shall include programmable logic controller and provide the following:
      a. NEMA 12 enclosure
      b. Circuit breaker disconnects for each pump with external operators
      c. Magnetic motor starters for each motor
      d. Single variable speed drive and full voltage motor starters
      e. Vacuum control switches
      f. Hand-off-automatic (H-O-A) selector switch
      g. Automatic lead/lag sequencing and automatic alternation of all pumps based on first-on/first-off principle with provisions for simultaneous operation, and reserve unit if required.
      h. Run time hour meters
      i. Visual/audible alarm indicators for all standard remote alarms
      j. Ethernet connectivity for remote monitoring
   4. Vibration Isolation: Refer to Section 23 0550 - Isolation Vibration.

PART 3 - EXECUTION

3.1 GENERAL

A. Medical gas systems shall be installed in conformance with requirements of NFPA 99.

B. Piping, fittings, valves and other components for medical gas systems shall be "Oxygen Clean".

C. Piping, fittings, valves and other components for medical vacuum, medical vacuum exhaust, waste gas evacuation, medical air intake, and instrument air intake are not required to be "Oxygen Clean".

D. Identify gas services during installation so that chance for cross over of one gas service to different terminal unit is avoided. Do not depend on test procedure listed herein to identify cross-connections.

E. Provide flexible connections as shown on details.

F. Equipment start-up shall be by manufacturer's representative in presence of Owner's representative.

G. Provide wiring necessary for float control switches, safety switches, solenoid valves and controls interface required.

H. Verify proper signal transmission for each condition specified to Building Automation Controller.

3.2 PIPE, FITTINGS AND JOINTS

A. Cleaned and capped tubing shall be new and delivered to job site with original mill caps in place.

B. Fittings shall be new and delivered to job site in sealed packages or with caps in place.

C. Fittings for medical gas use shall be stored in separate tool or gang box from non-medical gas fittings. Materials or tools, which have been contaminated with oil or grease shall not be stored with fittings for medical gas systems.

D. Cut copper tube square and ream before assembly. Keep piping capped during construction to prevent intrusion of construction debris.

E. Changes in direction shall be made by use of fittings. No pipe bending allowed. Pipe size reductions shall be by use of reducing fittings, no bushings allowed.

F. Support piping drops through finished ceiling from structure above to prevent any lateral or up/down movement. Other outlet drops shall be supported from walls, columns, or workbenches using appropriate hangers, anchors or Unistrut.

G. Provide plugs or caps for openings during construction phase. Temporary plug shall be plastic cap or equivalent.

H. Vacuum tubing, prior to installation, shall be labeled or identified to preclude using materials or installation procedures in the medical gas system that are not suitable for oxygen service. If medical gas tube is used for vacuum piping, special marking is not required.

3.3 BRAZED JOINTS

A. Systems with brazed joints shall be used for medical air, medical vacuum, oxygen, instrument air piping systems.

B. Contractor shall have brazing procedure specification addressing cleaning, joint preparation, overlap, internal purge gas, purge gas flow rate and filter material.

C. Brazing shall be performed by qualified fitters who have experience with brazing and working with high temperature torches.

D. No Borax, alcohol or similar paste flux shall be used.

E. Avoid prolonged heating and burning of joints during brazing.

F. Purge lines with dry nitrogen during brazing and provide apparatus required to perform purging.

3.4 SOLDERED JOINTS

A. Systems with soldered joints may be used for medical vacuum and WAGD exhaust piping, medical air and instrument air intake piping.

B. Use non-acidic and lead-free flux on cleaned pipe and fittings.

C. Fill joints with solder by capillary actions, with solder covering joint periphery. Wipe joints clean. Apply heat carefully to prevent overheating and damage to pipe, fittings and valves.

D. Strict adherence to manufacturer's installation recommendations when heating and soldering valves is mandatory.

3.5 THREADED (COPPER PIPE)

A. Screwed joints may be used on equipment connection. Threads shall conform to ANSI Standard B1.20.1. Apply teflon tape to male threads. No oil shall be used for cutting threads.

3.6 HANGERS

A. Hangers shall be in accordance with Section 20 0529 - Piping and Equipment Supporting Devices, except as modified herein.

3.7 SHUTOFF VALVES

A. Protect valves during brazing and/or soldering by wrapping valve body thoroughly with rag saturated with cold water. Rag shall be rinsed in cold water after each use and shall not be allowed to reach temperature warm to the touch.

B. Shutoff valves installed in ceiling spaces shall be provided with handle locks to secure valve in open position. Handle lock shall be provided with padlock. Padlocks used for securing medical gas piping shall be keyed alike. Five identical keys shall be provided to Owner when medical gas system is placed into service.

C. Shutoff valves shall not be installed in ceiling spaces unless that space is accessible. Accessible is defined as immediately adjacent to an access panel or above suspended acoustic tile system on which the tiles are not secured to grid or restricted in removal.

D. Shutoff valves, except riser isolation valves, shall be labeled in accordance with NFPA 99, 5.1.11.2. This applies to valves in zone valve boxes or valves installed in ceiling spaces.

3.8 ZONE VALVE BOX (ZVB)

A. Each valve shall be labeled to indicate rooms that are shut off by that particular valve.

B. Provide engraved, laminated plastic labels for each valve indicating rooms that are shut off by that particular valve. Labels to be similar to the picture below.

3.9 ALARMS

A. For alarm systems with pressure sensors mounted on the piping system, provide wiring necessary for controls and automation systems interface.

B. For area alarm system with pressure sensor mounted in the alarm panel, provide copper tubing from the panel to the branch or main location indicated on plan.

3.10 STATION OUTLET/INLETS

A. Station outlet/inlets shall be properly supported to wall studs by use of backing plate spanning stud-to-stud.

3.11 CLEANING

A. On-site cleaning shall be limited to recleaning of piping, valve and fitting surfaces in the immediate vicinity of the joints, which have become contaminated prior to brazing. If the entire pipe section, fitting or valve has been contaminated, it shall not be used in the medical gas system. It can be used in the medical vacuum system.

B. Cleaning shall be by washing in solution of sodium carbonate or trisodium phosphate mixed at concentration of 1 lb to 3 gal of potable water.

C. After washing, parts shall be thoroughly rinsed in clean hot (140°F) water.

D. After brazing, the outside of all joints shall be washed with water and wire brushed to remove residue and permit visual inspection of the joint.

3.12 MEDICAL AIR COMPRESSORS

A. Air compressor equipment shall be delivered pre-assembled and pre-tested by the equipment manufacturer. Modular units shall be permitted and shall require minimal field piping and wiring for installation.

B. Base-mounted pumps shall be anchored to structure in accordance with seismic restraint requirements. See Section 20 0549 - Seismic Anchorage and Restraints.

C. Provide vibration isolators for base or skid-mounted pumps.

D. Air intakes for medical compressed air systems shall have opening minimum of 10 ft from any building openings and minimum of 20 ft above ground. Intake shall be turned down with screen over opening to prevent the entry of vermin or water. Screening shall be stainless steel. An alternate source of supply air may be used if equal to or better than outside air.

3.13 MEDICAL VACUUM PUMPS

A. Vacuum pump equipment shall be delivered pre-assembled and pre-tested by equipment manufacturer. Modular units shall be permitted and shall require minimal field piping and wiring for installation.

B. Base-mounted pumps shall be anchored to structure in accordance with seismic restraint requirements. See Section 20 0549 - Seismic Anchorage and Restraints.

C. Provide vibration isolators for base or skid-mounted pumps.

D. Exhaust for medical vacuum and WAGD system shall discharge minimum 10 ft from any building openings. Exhaust shall be turned down with screen over opening to prevent the entry of vermin or water. Screening shall be stainless steel.

3.14 TESTING

A. Piping systems shall be blown clear with oil-free, dry nitrogen before station outlets/inlets and other components are installed.

B. Initial Pressure Test

1. Piping systems shall be tested with oil-free, dry nitrogen.

2. Pipe and fittings shall be tested at 150% of working pressure (minimum of 150 psi for medical gas and 60 psi for vacuum) for 2 h with no loss in pressure.
3. Soap test each joint to detect leaks during test period.
4. Pressure test shall be conducted after installation of station outlets/inlets rough-in assemblies and before pressure sensors, pressure relief valve, or other components are installed and before the closing of walls.
5. Leaks, if any, shall be repaired and entire system shall be retested.

C. Cross-connection test:
1. Source gas shall be disconnected and system piping vented to atmosphere.
2. Clean, oil-free, dry nitrogen at 50 psig shall be connected to single system at time.
3. After installation of faceplates with adapter matching outlet/inlet labels, each individual outlet/inlet in each medical gas and vacuum piping system shall be checked to determine test gas is being dispensed from piping system being tested.
4. Proper labeling and identification of system outlets/inlets shall be confirmed.

D. Piping Purge Test:
1. Test shall be conducted with oil-free, dry nitrogen.
2. Each outlet shall be purged with intermittent high-volume flow of test gas until there is no discoloration on white cloth held over the outlet.
3. Purging shall start with closest outlet/inlet to the zone valve and continue to the furthest outlet/inlet within the zone.

E. Standing Pressure Test:
1. After medical gas systems are installed including connections to station outlets, systems shall be subjected to 24 h standing pressure test at pressure of 120% of system normal operating pressure.
2. The source valve shall be closed during the test.
3. Test gas shall be oil-free, dry nitrogen.
4. The only allowable pressure change is that caused by variation of ambient temperature.
5. Leaks, if any, shall be repaired and entire system shall be retested.

F. Standing Vacuum Test:
1. After vacuum systems are installed including connections to station inlets, systems shall be subjected to 24 h standing vacuum test between 12” Hg and full vacuum.
2. Tests shall be conducted after installation of all components of vacuum system.
3. The only allowable vacuum change is that caused by variation of ambient temperature.
4. Leaks, if any, shall be repaired and entire system shall be retested.

G. When an existing medical gas system is being modified or expanded, testing shall be conducted on piping system before final connection is made to activate the system.

3.15 SYSTEM VERIFICATION

A. Verification shall be performed by independent testing agent hired by Contractor. Verification shall be performed after closing of walls and after completion of installer performance tests.

B. Standing Pressure Test:
1. Piping systems shall be tested with oil-free, dry nitrogen or source gas.
2. Source valves and all zone valves shall be closed.
3. Piping system shall be subject to a 10 minute standing pressure test at operating line pressure.
4. Leaks, if any, shall be repaired and entire system shall be retested.

C. Cross-connection Test:
   1. Individual Pressurization Method:
      a. Source gas shall be disconnected and system piping vented to atmosphere.
      b. Clean, oil-free, dry nitrogen at 50 psig shall be connected to single system at time.
      c. The appropriate adapter shall be used to verify that the test gas is dispensed only from station outlets/inlets of medical gas and vacuum systems being tested.
   2. Pressure Differential Method:
      a. Cross-connection verification may be conducted by pressurizing each medical gas system to different pressure, as follows:
         1). Gas pressures shall be maintained at:

Gas System	Pressure
Gas Mixtures	20 psig
Nitrogen/Instrument Air	30 psig
Nitrous Oxide	40 psig
Oxygen	50 psig
Medical Air	60 psig
Medical Vacuum	20” Hg
WAGD	15” Hg

         2). A pressure gauge connected to system specific connection shall be used to certify that the pressure/vacuum from each outlet/inlet on each system complies with the above pressures.

D. Valve Test:
   1. Each valve shall be tested to verify proper operation and rooms of control.
   2. Record all rooms or areas controlled by each valve for each gas.

E. Alarm Test:
   1. Warning systems for each medical gas and vacuum system shall be actuated and checked for proper setting to alarm panels.
   2. Test shall be conducted with oil-free, dry nitrogen.
   3. Where computer systems are used as substitutes for a required alarm panel, computer system shall be included in the alarm tests.

F. Piping Purge Test:
   1. Test shall be conducted with oil-free, dry nitrogen.
   2. Each outlet shall be subjected to heavy, intermittent purge of at least 8 scfm until there is no discoloration on white cloth held over the outlet.
   3. Cleanliness of each positive pressure gas system shall be verified by flowing minimum of 35 ft^3 of gas through clean, white, .45 micron filter at minimum flow rate of 3.5 scfm. Filter shall accrue no more than 0.1 mg of matter.
   4. Cleanliness test shall be conducted on the 25% of zones with outlets most remote from the source.
   5. Each patient medical gas system shall be tested for nonmethane hydrocarbons and halogenated hydrocarbons with the difference between source gas no greater than 5 ppm. Test shall be performed at the most remote outlet from source.

G. Final Tie-in Test:
   1. For any extension or addition to existing medical gas system, verification activities in the above sections shall be conducted on piping system before final connection is made to active system.
   2. Each joint between new work and existing system shall be leak-tested with source gas at normal operating pressure by means of soapy water. Vacuum joints shall be tested using an ultrasonic leak detector.
   3. Pressure gases for the specific altered zone and components in the immediate zone or area downstream from the point or area of intrusion shall be purged.
   4. Before systems are utilized, positive pressure bases shall be tested for operational pressure and gas concentration.

H. Operational Pressure Test:
   1. Each outlet tested on medical air, oxygen, nitrous oxide, and carbon dioxide systems shall deliver minimum of 3.5 scfm with static pressure of 50 psig to 55 psig and pressure drop of no more than 5 psi.
   2. Each outlet tested on nitrogen and instrument air systems shall deliver minimum of 5 scfm with static pressure of 160 psig to 185 psig and pressure drop of no more than 5 psi.
   3. Each inlet on vacuum systems shall draw 3 scfm without reducing the vacuum pressure below 12" Hg at any adjacent station inlet.
   4. Oxygen and medical air outlets serving critical care areas shall permit a transient flow of 6 scfm for 3 seconds.

I. Medical Gas Concentration Test:
   1. After final purge, each pressure gas shall be analyzed for concentration of gas, by volume.
   2. Allowable concentrations shall be within the following:

Gas System	Test Limits
Oxygen	> 99% oxygen
Nitrous Oxide	> 99% nitrous oxide
Nitrogen	< 1% oxygen or > 99% nitrogen
Medical Air	19.5% to 23.5% oxygen
Other Gases	± 1% labeled gas concentrate

J. Medical air purity test:
   1. Medical air source shall be analyzed to concentration of contaminants by volume, with the following limits:

Parameter	Limit
Dew Point	39°F @ 50 psig
CO	10 ppm
CO_2	500 ppm
Gaseous Hydrocarbons	25 ppm as methane
Halogenated Hydrocarbons	2 ppm

K. Labeling for all components shall be verified for presence and correctness.

L. Source Equipment Verification

1. Test function of actuating switch and signal to monitor contents and pressure reserve.
2. Air quality tests of medical air compressor system shall be performed after a minimum of 24 h of operation with a demand of approximately 25% of rated compressor capacity with compressors cycling on and off continuously and dryers operating for a 24 h period.
3. Medical vacuum pumps shall be tested for proper function.

M. Verification test report shall be submitted to Engineer for review prior to use of medical gas system. Systems shall not be considered in service until satisfactory test results are obtained, submitted and approved.

3.16 WARRANTY

A. Manufacturer shall warrant vacuum pumps and related accessories and components for period of 2 yrs from date of start-up.

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

END OF SECTION

SECTION 23 0000 GENERAL HVAC REQUIREMENTS

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 – Piping and Equipment 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

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 NOT APPLICABLE TO THIS SECTION.

END OF SECTION

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SECTION 23 0525 OWNER FURNISHED EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL

A. Certain pieces of equipment, which are required in the construction, will be purchased by Owner.

B. This Contractor shall be responsible for receipt from Owner, storage after receipt, and installation.

C. Owner-furnished equipment requiring work by this Contractor is specified in the following Sections:
   1. Section 23 7328 - Factory Fabricated Custom Air Handling Units

D. Owner Furnished Equipment, requiring work by this Contractor is shown on drawings and schedules. Owner Furnished, Contractor Installed Equipment is labeled OFCI.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Contractor shall install Owner Furnished Equipment as though Contractor had purchased equipment. This shall include, but not be limited to; receiving equipment at jobsite, rigging and setting equipment in place, making connections, starting, testing and installing equipment in accordance with manufacturer's recommendations, and maintaining equipment until such time as facility is accepted by Owner. Perform all work and provide materials and connections for Owner furnished equipment in accordance with drawings and scope of work under all Sections of Division 20 and 23.

B. Owner will make available shop drawings of Owner Furnished Equipment for review. Contractor shall review shop drawings to ascertain that Contractor has included necessary labor and materials to install equipment and complete system it serves.

C. After completion of equipment installation, assemble equipment shop drawings, operating/ maintenance instruction and part lists into this Contractor's project operation/maintenance manuals. Refer to Section 20 0000 - General Mechanical Requirements for additional requirements on operation/maintenance manuals.

3.2 CONTROLS

A. Provide necessary control equipment as described in Sections 23 0901 and 23 0993 for proper and stable operation of Owner Furnished Equipment as applicable.

3.3 TESTING AND BALANCING

A. Requirements of Section 23 0594 - Water Systems Test Adjust Balance and Section 23 0595 - Air Systems Test Adjust Balance shall apply to Owner Furnished Equipment.

B. Provide testing of Owner Furnished Equipment as described in associated specification sections and as recommended by manufacturer.

3.4 GUARANTEE

A. Furnish a written 1 yr guarantee on all work performed to install equipment. Also furnish a written 1 yr service agreement in connection with replacement of any parts of equipment installed. Contractor will have full right and authority to request replacement of Owner Furnished Equipment as if Contractor had purchased equipment originally.

END OF SECTION

SECTION 23 0550 VIBRATION ISOLATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0529 – Piping and Equipment Supporting Devices

B. Section 20 0549 - Seismic Anchorage and Restraints

C. Section 23 3114 – Ductwork (Ductwork Supporting Requirements)

D. Section 23 3314 - Ductwork Specialties (Duct Flexible Connections)

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 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 and pump over 25 hpshall be balanced in accordance with the following maximum rms velocity levels:
   1. Fans: 0.15 inch/sec
   2. Pumps:

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

   Allowable field pump vibration values above are based on HI 9.6-2000, Figure 9.6.4.12.

F. Final in-field balance shall be measured with each fan over 25 hp installed on springs specified for unit. Fans shall be loaded with design static pressure. Measurement shall be carried out in vertical, horizontal and axis planes at impeller shaft bearing location.

1.4 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.

1.5 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 and close coupled pumps, steel rails shall be used above mountings to compensate for overhang.

2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

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

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

2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above, but shall have 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 S BASES (STEEL BASE)

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

determined by manufacturer. Employ height saving brackets in all mounting locations to provide base clearance of at least 1" above floor or housekeeping pad.

2.8 TYPE I BASES (INERTIA BASE)

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

2.9 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.

2.10 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.

2.11 TYPE 7 HANGERS (SPRING HANGER WITH DEFLECTION INDICATOR)

A. Mason Type HES, steel spring in steel housing including deflection indicator scale. Hangers shall be preset at factory for required load. Select hangers so that actual loads do not exceed rated capacities (lbs).

B. Submittals shall include isolator rated deflection, required deflection and supporting calculation. Calculations shall be made by registered mechanical or civil engineer demonstrating structural adequacy of hanger and that hanger connections to building and pipe are adequate for live and dead loads encountered.

2.12 TYPE 8 HANGERS (SPRING HANGER WITH NEOPRENE)

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

2.13 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.

2.14 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.

2.15 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. Water System:
   1. Connection to Rotating Equipment:
      a. Connectors shall consist of Kevlar or Nylon tire cord fabric reinforced with EPDM cover and liner. Solid steel rings or steel wire shall be used within raised face rubber flanged ends to prevent pullout. Furnish connectors with control rods only where recommended by connector manufacturer.
      b. 2" and Smaller: Threaded connections, single sphere design similar to Mason SAFEFLEX SFU.
      c. 2-1/2" and Larger: Floating steel flange connections, two sphere design with ductile iron or plated carbon steel reinforcing rings, similar to Mason SAFEFLEX SFDEJ. Single sphere design similar to Mason SAFEFLEX SFEJ, may be used for 14" and larger.
   2. Connection to Non-rotating Equipment Mounted on Vibration Isolators:
      a. Seamless corrugated bronze or stainless steel flexible connector with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.

E. Steam and Condensate Including Pumped Condensate System:
   1. Seamless corrugated stainless steel flexible connector with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.

F. Compressed Air Systems:

1. Seamless corrugated bronze flexible connector with bronze wire braided cover for copper piping and seamless corrugated stainless steel flexible connector with braided cover for steel piping. Connector ends shall be threaded, soldered, or flanged to match piping system valve ends.

G. Do not provide flexible piping connectors for compressed air piping.

H. Do not provide flexible piping connectors for gas piping.

2.16 PERFORMANCE

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

Type of Equipment	Ground Supported Slab		Floor Span							
			Up to20 ft		20 ft to 30 ft		30 ft to 40 ft		40 ft to 50 ft	
	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)
Pumps:										
Inline	Support inline pumps by connected pipes if suspended or by pipe stands or support frame from floor as shown. No vibration isolation mounts are required. Provided spring hangers for connected piping as specified in this Section.									
Air Compressors:										
Tank Mounted Horizontal										
Thru 10 hp	3	0.75	3	0.75	3	1.5	3	1.5	3	2.5
15 hp and over	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Tank Mounted Vertical and Base Mounted										
All sizes	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Vacuum Pumps:										
Tank Mounted Horizontal										
Thru 10 hp	3	0.75	3	0.75	3	1.5	3	1.5	3	2.5
15 hp and over	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Tank Mounted Vertical and Base Mounted										
All Sizes	3-I	0.75	3-I	0.75	3-I	1.5	3-I	1.5	3-I	2.5
Utility Set Fans:										
Suspended	Use Type 5 hangers with deflection from blower minimum deflection guide, but not to exceed 2.5”.									
Floor Mounted	Use Type 2 for 0.75” deflection, Type 3 for 1.5” deflection and Type 3-S for over 1.5” deflection with deflection from blower minimum deflection guide, but not to exceed 2.5”.									
Roof Mounted	Use Type 4 mount with deflection from blower minimum deflection guide up to 0.75” deflection. Over 0.75” deflection, use Type 4-S mount.									
Centrifugal Blowers:										

Suspended	Use Type 5-T hangers with deflection from blower minimum deflection guide.
Floor Mounted	
Up to 22" diameter all sizes	Use Type 2 mount with 0.25" deflection for slab on grade, Type 3 mount with 0.75"deflection for floor span up to 30', and Type 3 mount with1.5" deflection for floor span over 30'.
24" diameter and up	
Thru 40 hp	Use Type 3-S mount with deflection from blower minimum deflection guide. Provide Type T thrust restraint for fans operating at 2" or more static pressure.
50 hp and over	Use Type 3-I mount with deflection from blower minimum deflection guide.
Axial Fans, Plenum Fans, Centrifugal Inline Fans, Cabinet Fans:	
Suspended	Use Type 5 hangers with deflection from blower minimum deflection guide. Use Type 5-T for over 4" static pressure.
Floor Mounted	
Up to 22" diameter all sizes	Use Type 2 mount with 0.25" deflection for slab on grade, Type 3 mount with 0.75"deflection for floor span up to 30 ft, and Type 3-I mount with1.5" deflection for floor span over 30 ft.
24" diameter and up	
Thru 2" WG SP	Use Type 3-S for slab on grade and floor span up to 20 ft, and Type 3-I mount for floor span over 20 ft with deflection from blower minimum deflection guide.
Over 2" WG SP	Use Type 3-I mount with deflection from blower minimum deflection guide.
Cooling Tower:	Use Type 1 mount for slab on grade and Type 4 mounts for floor/roof with deflection from blower minimum deflection guide.
Fan Coil Units, Heat Pump Units and Fan Powered Boxes	Type 5 with minimum deflection of 0.5" for 600 cfm or less and 0.75" for over 600 cfm.
Piping Connected to Rotating or Recipro-Equipment:	Use flexible piping connections, and Type 6 hangers for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater. Hangers shall have minimum deflection of 0.75" for pipe sizes 3" and smaller, 1.5" for pipe sizes 4" through 6" and 2.5" for pipe sizes 8" and larger. For piping less than 2" in diameter, neoprene or felt pad inserted between pipe or pipe covering and clamp or hanger may be used in lieu of Type 6 hangers. Where piping is floor-supported, above requirements shall apply, but use Type 3 mounts instead of hangers. Flexible piping connection shall not be used for unit heaters and in-line pumps that are supported by connected pipes. Type 6 hangers with 1" minimum deflection shall be applied within one foot of both sides of in-line pump and for distance of 100 pipe diameters or 50 ft away from first hanger at in-line pump, whichever is greater.
Piping 2.5" and Larger Supported from Underside of **5th** Floor:	Use Type 5 hangers with 0.75" minimum deflection.
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.
Ductwork in Mechanical Equipment Rooms:	Use Type 8 hangers with 0.75" minimum deflection for ducts with cross sectional area greater than 2.0 sq ft and where air velocity is greater than 2000 fpm for distance 50 ft from fan.
Ductwork Suspended Underneath **5th** Floor:	Use Type 8 hangers with 0.75" minimum static deflection for ductwork under the following circumstances: Air velocities greater than 2000 fpm and duct cross sectional area greater than or equal to 2.0 sq ft.

BLOWER MINIMUM DEFLECTION GUIDE

When blowers are 60 hp or larger, select deflection requirements for next larger span, but not less than 2-1/2".

		Required Deflection (Inches)			
Fan Speed (rpm)	On Grade	Up to 20 ft Floor Span	20 ft to 30 ft Floor Span	30 ft to 40 ft Floor Span	40 ft to 50 ft Floor Span
Up to 300	2.5	3.5	3.5	3.5	3.5
301-500	1.5	1.5	2.5	2.5	3.5
501 and over	0.75	1.5	1.5	2.5	3.5

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.

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

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

END OF SECTION

SECTION 23 0594 WATER SYSTEMS TEST ADJUST BALANCE

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 (balancing valves)

D. Section 23 2120 - Piping Specialties (flow measure devices)

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 DESCRIPTION

A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for HVAC hydronic systems, such as chillers, pumps, convertors and other processes included in this project.

B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.

C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.

D. Scope of work also includes TAB of existing HVAC hydronic systems as defined by drawings, schedules, or specified in this Section.

E. Work is limited to new areas within the construction boundaries and does not include central pumping equipment or other areas. Make attempts to balance flows to values indicated. If flow is low, attempt to proportional balance flows to the same percentage below design.

F. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC, NEBB or TABB Standards, ASHRAE - 2015 HVAC Applications Chapter 38, and as detailed herein.

G. Mechanical Contractors who are members of AABC, NEBB or TABB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor who will submit it for approval.

H. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including calibrated balancing valves, gauge tappings, flow sensors, and thermometer wells. Mechanical

Contractor shall be responsible for trimming and balancing pump impellers as necessary to obtain design pump flow rates at the minimum pressure differential.

I. TAB work shall not proceed until all assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.4 SUBMITTALS

A. General:
   1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless otherwise directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
   2. Reports shall be assembled using 3-ring hard cover binder with project name and location on cover and side panel. Information sheets shall be 8-1/2" x 11" white bond paper. Use pre-printed forms of NEBB, 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, NEBB or TABB 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 technicians resumes
   2. Architect/Engineer and/or Owner reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Owner feel are not qualified for this project due to lack of relevant experience or problems on previous projects.

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

D. Initial Test Report:

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

E. Final Report:

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

1.5 REFERENCE STANDARDS

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

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

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

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

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 shall be ± 10% of design flow rates indicated on drawings and schedules.

3.2 PLANNING PHASE

A. Procedure:

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

B. Planning Report:

1. Planning Report shall contain the following minimum requirements.
2. Narratives: Furnish written narratives of procedures to be used. Include separate narratives for each pump and liquid fluid handling system. Identify flow-measuring devices to be used at each pump and terminal device. Include different narratives for constant and variable flow systems. For non-standard water systems, include narratives on how to measure and adjust for different viscosities. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include

measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.

3. Prebalance Checklist shall include, but not be limited to:
   a. Check for completeness of work
   b. System cleaning
   c. System fill and air venting
   d. Place system into operation
   e. Check expansion tanks and fill pressures
   f. Pump bearings, alignment, starters, vibration isolators, rotation
   g. Setting valves to proper position including shut-off and bypass valves
   h. Set up of controls and control devices
4. Measuring Instrument List: List of measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
   a. Manufacturer name and model number
   b. Measurement range
   c. Pressure/temperature limits
   d. Date put into service
   e. Date of last calibration
   f. Certificate from calibration firm
5. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument that has not been recalibrated within past year.
6. Samples: Submit copies of TAB forms to be used.
7. Branch circuit and terminal measurements and adjustments: Indicate on pre-printed forms all measurements to be taken and adjustments to be made in field. Include branch circuit or terminal identification, system, space served, location, design flow rates (including zone and system summaries), and flow measuring device size, type, Cv, and manufacturer. Indicate the initial set points on forms.

3.3 SET-UP PHASE

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

B. Initial Test:
   1. Measure pump data and flow rates in "as found" condition after initial valve settings are made.

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

3.4 FINAL BALANCE PHASE

A. Procedure:
   1. Perform procedures as per Planning Phase narrative. Correct deficiencies and redo procedures as required prior to submitting Final Report.

B. Final Report:

1. Submit report to Architect/Engineer and to Mechanical Contractor indicating all data, measurements and adjustments as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.

C. Final Report Adjustments:

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

END OF SECTION

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SECTION 23 0595 AIR SYSTEMS TEST ADJUST BALANCE

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 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 DESCRIPTION

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

B. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.

C. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.

D. Scope of work also includes TAB of existing air systems as defined by drawings, schedules, or specified in this Section.

E. All existing air systems within scope of demolition/renovation areas shall be rebalanced as necessary to provide new air flows as indicated on drawings. This shall include measurements of existing system air flows prior to demolition and confirmation that air flows to all spaces served by systems being modified are equal to air flows that existed prior to work being started.

F. 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.

G. 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.

H. TAB Contractor shall perform ductwork leakage tests. Refer to Section 23 3114 - Ductwork. Test equipment will be provided by Mechanical Contractor.

I. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including fan sheaves, motor sheaves and/or drive belts.

J. TAB work shall not proceed until assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.4 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.

F. LEED Submittal:

1. Air Balance Report for LEED IEQ Prerequisite 1: Documentation of work performed for ASHRAE 62.1-2007, Section 7.2.2, “Air Balancing”.

1.5 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. Obtain and record all airflow and pressure setpoints for all existing spaces served by air handling unit AHU-DT-21AW, this includes but is not limited to surgery waiting, pharmacy, IDF/EIDF and electrical closets, and public spaces. Prior to the start of any demolition the contractor shall perform a test and take airflow measurements as needed to confirm the performance of the existing supply and return air terminal units. Coordinate with the owner prior to proceeding. After completion of construction the contractor shall perform tests and take measurements as needed to confirm the performance of the existing supply and return air terminal units is equal to the performance that existed prior to work being started.

C. 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.

D. For spaces where supply airflow rates and exhaust airflow rates are used to maintain pressure relationships, such as isolation rooms and procedure rooms, maximum acceptable supply air offset shall be 0 to +10% of design flow rate. Associated exhaust air (or return air) flow rate shall be balanced to provide indicated airflow differential between supply air and exhaust air (or return air) after supply air system has been balanced.

E. For Airborne Infectious Isolation (AII) rooms, isolation rooms, Protective Environment (PE) rooms, and other negative and positive pressure rooms provided with pressure differential monitoring devices, TAB contractor shall initially balance rooms to supply air and return/exhaust air offsets indicated on drawings. Space pressure monitors shall be set to alarm as indicated below:

Space Description	Alarm Setpoint (in. w.c.)	Minimum Initial Pressure Differential (in. w.c.)
AII, isolation, and negative pressure rooms	-0.01	-0.015
PE rooms, Burn ICU, and positive pressure rooms	0.01	0.015

1. TAB contractor shall confirm and coordinate balance schedule with completion of all partition wall penetrations and door seals prior to completion of balance work.
2. During initial balancing to the indicated supply and return/exhaust air offsets, TAB contractor shall record pressure differential as observed at space pressure monitor in TAB reports. Minimum initial pressure differential shall be as indicated in the above table.
3. If initial offsets do not meet specified minimum pressure differential, TAB contractor shall incrementally increase (50 CFM) exhaust air flow offset from negative pressure rooms until minimum pressure differential is achieved and record final offset and pressure differential in TAB report.
4. If initial offsets do not meet specified minimum pressure differential, TAB contractor shall incrementally decrease (50 CFM) return or exhaust air flow offset from positive pressure rooms until minimum pressure differential is achieved and record final offset and pressure differential in TAB report.
5. Associated return or exhaust fan speeds shall be adjusted as necessary to meet space pressure differential setpoints.

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). Isolation Rooms

2). Procedure 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. For hoods and ovens indicate temperature and humidity. Correct for density changes.

o. 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 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to Section 019100.

C. Commissioning requires the participation of the Division 23 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019100. Division 23 Contractor shall be familiar with all parts of Section 019100 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of Section 019100.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 019100 - Commissioning
2. Section 220800 - Commissioning of Plumbing
3. Section 260800 - Commissioning of Electrical
4. Section 270800 - Commissioning of Communications

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.
2. Infrared thermometer gun.
3. Analog differential pressure gauge and associated tubing.
4. Portable computer with access to the building automation system.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°°F and a resolution of +/- 0.1°°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 019100 for additional Division 23 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of Section 019100.

END OF SECTION - 230800

SECTION 23 0901 CONTROL SYSTEMS INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 01-9913 – Building Systems Commissioning

B. Section 20-0000 – General Mechanical Requirements

C. Section 20 0513 – Motors

D. Section 23 0550 - Vibration Isolation

E. Section 20-0553 – Mechanical System Identification

F. Section 23 0902 - Control Valves and Dampers

G. Section 23 0903 - Control Instrumentation

H. Section 23 0923 - Direct Digital Controllers and Networks

I. Section 23 0924 - Graphical User Interface Integration

J. Section 23 0993 - Control Sequences

K. Section 23 2118 - Valves

L. Section 23 3600 - Air Terminal Devices

M. Section 23 3614 - Laboratory Temperature and Airflow Control System

N. Section 26 0000 - General Electrical Requirements

O. Section 26 0533 - Raceway and Fittings

P. Section 26 0519 - Conductors and Cables

Q. Section 23-3614 – Pressure Relationship, Temperature and Airflow Control System

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

S. Section 26-0533 – Raceway and Boxes for Electrical Systems

T. Section 26-0926 – Lighting Control Systems

U. Section 26-2300 – Low Voltage Switchgear

V. Section 26-2713 – Electrical Metering

W. Section 28-3116 – Multiplexed Fire Detection and Alarm Systems

1.2 REFERENCE

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

B. ASHRAE FUN IP - (2013) Fundamentals Handbook, I-P Edition

C. ASHRAE 135 - (2012) BACnet - A Data Communication Protocol for Building Automation and Control Networks (ANSI Approved) .13

D. Electrical Standards: Provide electrical components of pneumatic control systems which have been UL listed and labeled, and comply with NEMA standards.

E. NFPA Compliance: Comply with NFPA 90A "Standard for the installation of Air Conditioning and Ventilating Systems" where applicable for controls and control sequences.

F. Kentucky Building Code: Comply with requirements where applicable for controls.

G. BUILDING SYSTEMS COMMISSIONING

1. "An independent third party Commissioning Agent will document completion of the Mechanical, Fire Suppression, Plumbing, HVAC, Electrical, Communications and Electronic Safety and Security Systems for the project. The Construction Manager, Division Contractors, and Control Contractor are members of the Commissioning Team and will facilitate completion of the Commissioning process. Refer to section 019113 "Building Systems Commissioning" for the project Commissioning requirements and roles and responsibilities of each member of the Commissioning Team."

1.3 DEFINITIONS

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

1.	Actuator:	Control device to provide motion of valve or damper in response to control signal.
2.	AI:	Analog Input
3.	AO:	Analog Output
4.	Analog:	Continuously variable state over stated range of values
5.	Auto-Tune:	Software routine used to adjust tuning parameters based on historical data.
6.	BAS:	Building Automation System
7.	BMS	Building Management System
8.	DDC:	Direct Digital Control
9.	DDCP:	Direct Digital Control Panel
10.	Discrete:	Binary or digital state
11.	DI:	Discrete Input (Sometimes referred to as Binary Input BI)
12.	DO:	Discrete Output (Sometimes referred to as Binary Output BO)
13.	EMCS:	Energy Management and Control System (Typically interchangeable with BAS or BMS)
14.	E/P:	Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
15.	FA	Field Adjustable
16.	FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.

17. FMS: Facility Management System linking two or more BAS
18. FO: Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
19. I/P: Current to pneumatic transducer
20. Instrument: Device used for sensing input parameters or used for actuation.
21. Modulating: Movement of control device through an entire range of values proportional to an infinitely variable input value.
22. Motorized: Control device with actuator
23. NC: Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
24. NO: Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
25. Node: DDCP, operator workstation, or other control device connected to communications network.
26. Operator: Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
27. PC: Personal Computer
28. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
29. P: Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
30. PI: Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
31. PID: Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
32. Point: Analog or discrete instrument with addressable database value.
33. Self-Tune: Same as Auto-Tune
34. Solenoid: Electric two-position actuator. (See E/P.)
35. TCC: Temperature Control Contractor (Same as Control Contractor)
36. TCP: Temperature Control Panel

1.4 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full service office within 100 miles of project site. Full service office is defined as being home office of applications engineers, supervisors, and field technicians, having complete parts inventory, and having required test and diagnostic equipment.

B. Acceptable controls manufacturers shall include any controls manufacturers which utilize a BACnet protocol in accordance with the specification. If the bidding manufacturer is not listed above, documentation for approval as an equal must be submitted 10 days prior to the bid opening date to allow for evaluation by the university.

C. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:

1. Tier 1 BACnet/IP controls
   a. Vykon
   b. Johnson Controls, Inc.
   c. Alerton Technology
2. Tier 2 Controls – BACnet/MSTP
   a. Honeywell
   b. Johnson Controls
   c. Alerton
   d. Distech

D. Installing Contractor: Installing controls contractors must comply with the following requirements:
   1. The systems integration contractor must have on staff the following number of key personnel as a minimum each with a minimum of 5 years of related controls installation experience, and a minimum of 3 hospital or university renovation projects of similar size and scope where they utilized a BACnet system.:
      a. Project Manager – 2 years
      b. Controls applications Engineer – 2 years
      c. Programmer – 2 years
      d. Installation Supervisor – 2 years
      e. Controls Technician – 5 years
   2. Prefer contractor staff to include Niagara Tridium AX or N4 certified technicians, and one advanced certified.
   3. Have experience with successful integrations of controls with Niagara Tridium systems.

E. Contractor to have a minimum of 3 years of installation history with the brand of controls being bid.

F. Contractor must have help desk operation or staff available for phone contact 24/7 for providing technical support to university staff. Call forward and emergency service numbers are not acceptable during normal business hours.

G. Bids will be accepted only from prequalified Control Contractor per "Instruction to Bidders".

1.5 SYSTEMS DESCRIPTION

A. Control system shall be Direct Digital Control (DDC).

B. Damper and valve actuators shall be electronic type, unless otherwise noted.

C. Control system shall be 100% DDC unless otherwise indicated.

D. Furnish a BACnet system compatible with existing University systems. All building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2001, BACnet. The system shall communicate with the University of Kentucky Facility Management's existing BACnet head-end software using BACnet/IP at the tier 1 level and BACnet/MSTP at the tier 2 level. No gateways shall be used for communication to controllers installed under section BACnet/MSTP or BACnet/IP shall be used for all other tiers of communication. No servers shall be used for communication to controllers installed under this section. If servers are required, all hardware and operating systems must be approved by the Facilities Management Controls Engineering Manager and/or the Facilities Management Information Technology Manager.

E. All Building Automation Devices should be located behind the University firewall, but outside of the Medical Center Firewall and on the environmental VLAN.

F. . BAS shall be fully expandable with addition of BACnet based hardware and/or software. Expansion shall not require removal of existing DDCPs, sensors, actuators, or communication networks.

G. System must be able to communicate with Tridium Niagara Framework at the University Medical Center via Protocol Address assigned by the University at the building location. Provide PICS for Windows-based control software and every controller in system, including unitary controllers. PICS and BIBBS shall comply with Tridium PICS and BIBBS.

H. Provide all necessary hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers. These must be in compliance with Front End systems PICS and BIBBS and attached Tridium PICS and BIBBS. Provide all hardware and software to backup, restore, troubleshoot and install system. Software, backups, unitary, and ASC files shall be delivered to UEM (Utilities & Energy Management) for archiving purposes.Ethernet network cabling shall be installed by Division 27 contractor with cable runs from central EIDF/IDF communication closet to multiple central locations on each floor. Ethernet cabling shall be utilized for BAS BACnet/IP communication from each zone to the existing BAS operator workstation. Controls contractor shall provide BACnet/IP to BACnet/MSTP small capacity Building Level Controller in each zone. BACnet/MSTP communication network shall be provided and installed by controls contractor between each room level controller in zones to BACnet/IP to BACnet/MSTP Building Level Controller. BACnet/MSTP communication network node capacity for each small capacity Building Level Controller zone shall be limited to a maximum of 80% manufacturer's recommended DDC controller capacity or 25 devices per trunk total, whichever total number of nodes is smaller

I. It is the contractor's responsibility to insure that the University of Kentucky Facilities Management's head-end system's licensed device/point count is increased to accommodate the number of devices and/or points that are added to fulfill the contractor's obligation to meet the requirements of the project.

J. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

K. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

L. Provide a comprehensive operator, administrator and technician training program as described herein.

M. Provide as-built documentation, programming software for use site wide, electronic copies of all diagrams, and all other associated project operational documentation (such as technical manuals on approved media, the sum total of which accurately represents the final system.

N. Furnish, install, and fit-up in complete working order, with all accessories required, the automatic temperature control and monitoring systems shown on the Drawings and specified herein. The systems shall be properly connected, piped and wired in a manner conforming to the laws, ordinances and codes now in force in the Commonwealth of Kentucky.

O. System intelligence shall be such that existing operator workstation(s) can be used for programming controls, performing analysis on filed data, perform trending of user defined inputs, generating maintenance and operation reports and providing permanent storage for programs and data, and the ability to connect to the Internet.

P. System shall be web-based, telnet or HyperTerminal capable. No graphics shall be provided. All graphics will be owner provided to existing Tridium system.

Q. All building automation products utilizing BACnet shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2001, BACnet and be tested by BACnet Testing Laboratories (BTL) and have passed the necessary requirements for BACnet compliance and interoperability.

R. New BAS shall seamlessly integrate with existing site **Tridium** web server. Existing web server shall be able to access and read all input, output and calculated points and issue commands to all output points in new BAS by means of a standard web browser. Contractor shall provide necessary hardware and software components to accomplish this interface.

S. Provide modular designed stand-alone controllers capable of future BAS architecture with peer-to-peer and/or low/medium speed communication networks. Upgrade to full BAS architecture shall not require removal of existing controllers, sensors, actuators, etc.

T. Provide DDC controls for the air terminal units. Provide electronic operators controlled and monitored by direct digital control systems which shall include, but not be limited to, air handling systems, pumps, terminal units, etc.

U. The control equipment shall be complete and shall include, but not be limited to, all necessary valves, damper operators, pipe, fittings, etc.

V. The control and monitoring system for this project shall be made up using standard materials, equipment and components regularly manufactured for systems of this type. The system shall be complete in every respect and shall be a functioning system.

W. Electronic Control System installer must physically demonstrate to Owner and Owner's representatives (UEM) via software simulations that the proposed building automation system and control sequences will function as outlined in the contract documents prior to field implementation.

X. Electrical power wiring and interlock wiring for all controls, signal devices, equipment, alarms, etc., shall be in accordance with diagrams and instructions from the supplier of the systems. All power and control wiring, conduit and wiring connections required for the complete installation, including wiring to smoke dampers and combination fire/smoke dampers and their motors, shall be provided by this Contractor in accordance with Electrical specification requirements. Controls shall be on emergency power.

Y. BAS network architecture shall be based on an Open implementation of BACnet using ASHRAE 135-2012 exclusively as the communications protocol for communication between DDC Hardware devices, including BAS Web Server, to allow multi-vendor interoperability.

Z. Building Automation System (BAS) shall control building's HVAC components and provide interface with Lighting Control System.

AA. Division 27 Contractor shall provide Ethernet work connections for BAS equipment requiring network connects.

BB. Provide BAS architecture consisting of communication network, operator workstations, web servers and modular designed controllers with all points addressable and modifiable from operator workstations or from master controller using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing controllers, sensors, actuators, or communication networks.

CC. System shall support operator workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.

DD. Operator workstations connected to building Ethernet network shall be able to access BAS information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox, Opera, or Google Chrome). GUI software shall allow transparent access to each building component/system for control and/or monitoring.

EE. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.

FF. Workstation PCs and printers will be furnished by Owner. Provide hardware interface card to communicate with BAS Network and required software for each workstation, as defined in this Section, to make each PC full function workstation.

GG. The controls and all listed I/O points from this project shall communicate with the University of Kentucky Facilities Management's existing BACnet software head-end station using BACnet/IP. All BACnet points shall be exposed to the University of Kentucky Facilities Management's head-end station. Graphics will be installed by UEM on the head-end system. All point and device names shall comply with the University Facilities Management standards and shall be approved before and included in the shop drawings submittal. Cooperate with the Owner (UEM) to ensure that all specified points and alarms communicate and operate on the head-end system. All point and device names shall comply with the University Facilities Management standards (format listed below, consult Utilities and Energy Management (UEM) for the correct abbreviations) and shall be included in the shop drawings submittal for review and approval. Point naming conventions and formats are listed further in this specification in the Direct Digital Controls Equipment section. Refer to University Standard 230553S02 for the AHU Naming Convention.

HH. Related to the alarms, the contractor is to set up the alarm parameters specified by the system sequences of operations without enabling the alarms. Contractor is to provide a list of points containing alarm extensions to Owner (UEM). UEM will be responsible for doing the alarm names, alarm texts and enabling the alarm points provided on the list.

II. Provide products of the temperature control system with the following agency approvals:
    1. UL-916; Energy Management Systems
    2. UL-873; Temperature Indication and Regulating Equipment
    3. UL-864; Subcategories UUKL, OUXX, UDTZ; Fire Signaling and Smoke Control Systems
    4. CSA; Canadian Standards Association
    5. FCC, Part 15, Subpart J., Class A Computing Devices

JJ. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, NEC, Local and National Codes.

KK. All work must be coordinated and scheduled with the UEM Controls group prior to any work being done on site.

LL. Refer to other Mechanical Division sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.
    1.

1.6 SCOPE OF WORK

A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents including this Section plus:
   1. Section 23 0902 - Control Valves and Dampers
   2. Section 23 0903 - Control Instrumentation
   3. Section 23 0923 - Direct Digital Controllers and Networks
   4. Section 23 0993 - Control Sequences
   5. Section 23-3600 – Air Terminal Devices
   6. Section 23-3614 – Pressure Relationship, Temperature and Airflow Control System

B. Engineering services shall be performed by factory trained engineers that are employed by the control manufacturer. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Owner reserves the right to exclude any project managers, engineers, field supervisors, or technicians whose past experience are not sufficient to meet needs of project. The manufacturer shall be responsible for the engineering, installation, startup, checkout, commissioning and warranty of control systems.

C. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Engineer reserves right to exclude Project Managers, Engineers, Field Supervisors, or Technicians whose past experience is not sufficient to meet needs of Project.

D. Control Contractor’s Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.

E. Submit qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this Project within 30 days after contract award. Use Qualification Form attached at end of this Section.

F. Labor shall include, but not be limited to:
   1. Engineering services to size unscheduled valves and dampers based on design criteria specified in Section 23 0902 - Control Valves and Dampers, and confirm sizing of scheduled valves and dampers.
   2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
   3. Engineering services for required software programming including integration of all BAS functionality into existing Tridium BAS.
   4. Engineering services for mapping control points from Laboratory Temperature and Airflow Control System (Section 23 3614), if provided for the project.
   5. Engineering services for BAS Ethernet network design.
   6. Project management services as single point contact to coordinate construction related activities.
   7. Field mechanics for installation of control wiring and related control devices.
   8. Field technicians to startup, calibrate, adjust, and tune control loops.
   9. Field technicians to perform system checkout and testing, and to complete required reports.
   10. Field supervisor during controls installation and startup.
   11. Field technicians to assist Mechanical Contractor and Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
   12. Field representatives and/or classroom instructors to provide Owner training as specified.

G. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring terminations at controller locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.

1. Control contractor shall provide unique tag numbers for all devices under this specification and reference those tag numbers in control sequences and control diagrams.
2. If Owner has tagging convention, Control contractor shall utilize it. If no tagging convention exists, Control contractor shall provide one for all devices under this specification.

H. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by air terminal unit manufacturer for air terminal unit manufacturer's factory mounting. Control Contractor shall coordinate with Air Terminal Unit manufacturer for timely delivery and for proper factory installation.

I. Mechanical Contractor shall provide wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.

J. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor is responsible for providing final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.

1. Electrical Contractor will provide circuit breakers required to provide electrical power to controllers.
2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to controller panels or in Equipment Intermediate Distribution Frame (EIDF) rooms and powered from dedicated electrical circuit.
3. Should any change in number of controllers or addition of other electrical equipment after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of Control Contractor.
4. Coordinate with Electrical Contractor for additional power requirements.

K. Fully functioning BAS Ethernet network, including all hardware (horizontal network cabling, routers, switches, firewalls, patch panels, patch cords, cabinets, etc.), is provided by the University and division 27 contractor.

L. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

M. If during the installation period any of the factory equipment or material provided in the system is found to be defective in material or workmanship, it shall be replaced or repaired by the Control Contractor within a two day working period from the time the problem was reported at no additional cost to the Owner.

N. Any part/device or equipment installed as part of this contract found to be malfunctioning or defective during the warranty period shall be replaced by the Contractor within a two day working period from the time the problem was reported.

O. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.

P. Control Contractor is responsible for integration of the following independent systems into the Control System.
   1. Low Voltage Switchgear.
      a. Low Voltage Switchgear provider will supply a data port for communication with BAS. BAS contractor shall coordinate and provide communication connection via BACnet/IP or BACnet/MSTP from data port to the BAS. BAS contractor shall supply cabling, conduit, and gateway/integrator necessary to make an interface connection from the gateway/integrator to the Low Voltage Switchgear data port. BAS contractor responsible for a BAS solution to communicate data directly or through a gateway/integrator to all suppliers listed in Division 26 for Low Voltage Switchgear bidders. BAS contractor and Low Voltage Switchgear provider shall be responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. BAS contractor to refer to Section 26 2300 – Low Voltage Switchgear and Section 23 0992 – DDC Point List for programming and monitoring requirements.
   2. Lighting Control System (LCS):
      a. LCS provider will provide appropriate network termination points for connection to BAS. Contractor shall supply cabling, conduit, and gateway (if necessary) to make an interface connection from BAS to LCS point of connection. Contractor is responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 26 for LCS bidders. Contractor and LCS provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to refer to P&ID's, DDC Point Schedules, and Division 26 for programming and monitoring requirements.

Q. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

R. Provide tamper resistant screws and fasteners for equipment located in accessible and/or public areas.

S. Contractor is responsible for integration of the following independent systems into BAS:
   1. Electrical Metering:
      a. Electrical Metering provider will provide BACnet/IP connection(s) for interfacing to BAS. Control contractor responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 26 for Electrical Metering. Control contractor and Electrical Metering provider responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. Control contractor to refer to P&ID's, Section 26 2413 Switchboards and Section 26 2713 Electrical Metering for programming and monitoring requirements.

1.7 SUBMITTALS

A. Extended Service Agreement:
   1. Control manufacturer shall, upon completion of warranty period, make available to Owner annual service agreement covering all labor and material required to effectively maintain control system after warranty period. Owner reserves the right to accept or reject any such offers and to cancel on-going agreements with 30-day written notice.
   2. During extended service period, Contractor shall maintain Operation and Maintenance manuals to reflect all changes made to BAS.

3. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; BAS Contractor name, address and phone number; BAS Contractor project manager, quality control manager, and project engineer names and phone numbers.

B. Shop Drawings:

1. Submit manufacturer's printed product data sheets for control devices and materials listed in bill of material in Control Contractor's control drawings. An index listing of all control devices and equipment applicable to project to be listed in the following format:
   a. Room #
   b. Device Part #
   c. Device Description
   d. Sheet # where cut sheet is located
2. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. If more than 20 product data sheets are submitted, provide front index and tabs for logical groups of devices. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Data sheets shall include sufficient technical data to describe instrument parameters required as specified. Refer to Specification section 20-0000 General Mechanical Requirements for additional submittal requirements and formatting. Data sheets shall include sufficient technical data to describe instrument parameters required as specified in Section 23 0903 - Control Instrumentation.
3. BAS manuals to be in two parts: 1) Operation and maintenance, and 2) System application manuals.
4. One (6) hard copy and (1) electronic copy of BAS manuals shall be provided to Physical Plant by BAS contractor at date of submittal completion.
5. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
6. Submit control drawings including, but not limited to, the following:
   a. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; BAS Contractor name, address and phone number; BAS Contractor project manager, quality control manager, and project engineer names and phone numbers.
   b. Front sheet index for projects with more than 10 control drawing sheets.
   c. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other. Label room location of each device. Number and indicate model number of each device. Indicate network types.
      1). BAS riser diagram showing all DDC controllers, network repeaters, and network wiring.
   d. Control Drawings: Including graphic representation of systems with major in-line components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
      1). One-line schematics and system flow diagrams showing the location of all control devices.
   e. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components.
      1). Detailed Bill of Material list for each panel, identifying: quantity, part number, description, and associated options.
   f. Bill of material identifying actual product model number used for each control device for each schematic control drawing.

g. Drawings showing proposed locations of sensors and flow meters in ductwork and piping systems.

h. Vendor's own written description for each sequence of operations, to include the following:

1). Sequences shall reference input/output and software parameters by name and description.

2). The sequences of operations provided in the submittal by the BAS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.

3). Points shall be referenced by name, including all software points such as programmable setpoints, range limits, time delays, and so forth.

4). The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system.

i. BACnet Compliance Documentation: The Protocol Implementation Conformance Statement for each component.

j. Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number. The initial shop drawing submittal for review needs to include all point names meeting the naming convention outlined in this specification for UEM approval at the shop drawing phase prior to the contractor beginning any programming.

k. Control Damper Schedules. This spreadsheet type schedule shall include a separate line for each damper and a column for each of the damper attributes, including:

1). Code Number,

2). Fail Position,

3). Damper Type

4). Damper Operator

5). Blade Type

6). Bearing Type

7). Seals

8). Duct Size

9). Damper Size

10). Mounting

11). Actuator Type.

l. Control Valve Schedules. This spreadsheet type schedule shall include a separate line for each valve and a column for each of the valve attributes, including:

1). Code Number

2). Configuration

3). Fail Position

4). Pipe Size

5). Valve Size

6). Body Configuration

7). Close off Pressure

8). Capacity

9). Valve CV

10). Calc CV

11). Design Pressure

12). Actual Pressure

13). Actuator Type.

m. Cataloged cut sheets of all equipment used. All models used shall be highlighted. This includes, but is not limited to, the following: DDC panels, peripherals, sensors, actuators, dampers, and so forth.

n. Submit manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes, also include installation and start up instructions.

o. Range and scale information for all transmitters and sensors. This sheet shall clearly indicate one device and any applicable options. Where more than one device to be used is on a single sheet, submit two sheets, individually marked.

p. Hardware data sheets for all local access panels.

q. Software manuals for all applications programs to be provided as a part of the programming devices, and so forth for evaluation for compliance with the performance requirements of this Specification.

r. The controls contractor shall include their BACnet PICS and BIBB statements (as described in ASHRAE 135-2001) for each device.

s. BAS Contractor shall not order material or begin fabrication or field installation until receiving authorization to proceed in the form of an approved submittal. BAS Contractor shall be solely responsible for the removal and replacement of any item not approved by submittal at no cost to the Owner.

t. Submittal shall have approved point names.

1). Refer to 230923 for point naming conventions and formats.

C. Operation and Maintenance Manuals

1. Maintenance Data:

a. Submit maintenance instructions and spare parts lists for each type of control device. Include that type data, product and shop drawings in maintenance manual.

b. This contractor shall prepare an electronic Operations Manual entitled "Automatic Temperature Control and Monitoring Systems Operation and Maintenance Data." Manual shall be PDF files with separate PDFs for each of the items noted below.

c. Each manual shall contain the following information:

1). Name and address of Consulting Engineer, Contractor, and index of equipment, including vendor (name and address).

2). Complete brochures, descriptive data and parts list, etc., on each piece of equipment, including all approved shop drawings.

3). Complete maintenance and operating instructions, prepared by the manufacturer, on each major piece of equipment, including preventative maintenance instructions.

4). Complete shop drawing submittal on temperature and monitoring controls including control diagrams updated to reflect "as built" conditions.

5). All wiring and component schematics necessary for Owner (UEM) to troubleshoot, repair and expand the system.

6). All manuals shall be submitted to the Engineer prior to final inspection of the building.

7). Provide a laminated copy mounted in a sleeve on the outside of the panels for the controls sequences pertinent to equipment supplied by that specific controls panel.

2. Layout Design Drawing for each control panel:

a. The layout drawing shall be to scale with all devices shown in their proposed positions.

b. All control devices shall be identified by name.

c. All terminal strips and wire channels shall be shown.

d. All control transformers shall be shown.

e. All 120 VAC receptacles shall be shown.

f. All IP connection points shall be shown.

3. Wiring/Pneumatic Design Diagram for each control panel.
   a. The control voltage wiring diagram shall clearly designate devices powered by each control transformer. If the control devices use half wave power, the diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
   b. The Field Bus wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the Field Bus, and the location of end of segment termination devices. All wire identification numbers shall be annotated on the diagram.
   c. If shielded communication wiring is used, the grounding of the shield shall be shown.
   d. The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.
   e. Detailed piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines with field ID numbers/colors.
4. Wiring Design Diagram for individual components (controllers, protocol translators, etc.): The wiring diagram for each component shall identify all I/O, power, and communication wiring and the locations on the terminal blocks to which the wires are landed. Example: Fan Status sensor is wired from terminals 5/6 on the controller to terminals 17 and 18 on the terminal strip.
5. Installation Design Detail for each I/O device.
   a. A drawing of the wiring details for each sensor and/or end device.
   b. For devices with multiple quantities, a standard detail may be submitted.
6. A System Flow Design Diagram for each controlled system.
   a. A two dimensional cross sectional diagram showing key components such as fans, coils, dampers, valves, pump, etc.
   b. Identify the locations and names of all sensors and end devices that are associated with the control system. Label the panel name and terminal numbers where the connections are landed.
   c. A legend shall be provided for all symbols used.
7. BACnet Compliance Documentation:
   a. The Protocol Implementation Conformance Statement (PICS) for each component.
8. Direct Digital Control System Hardware Technical Data.
   a. A complete bill of materials of equipment to be used indicating quantity, manufacturer, and model number.
   b. Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets, and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
   c. This requirement applies to:
      1). Controllers
      2). Transducers/Transmitters
      3). Sensors
      4). Actuators
      5). Valves

6). Relays and Switches
7). Control Panels
8). Power Supplies
9). Batteries

9. An Instrumentation List for each controlled system.
   a. The list shall be in a table format.
   b. Include name, type of device, manufacturer, model number, and product data sheet number.
10. Sequence of Control: A sequence of control for each system being controlled. Include the following as a minimum.
   a. Process control sequence for each end device.
   b. Supervisory logic sequence of control for each system.
   c. The impact of each global application program on the sequence of control (Example: Demand Control).
   d. A list of all physical inputs and outputs associated with each sequence.
   e. Within the sequence of control, all application parameters that are to be user adjustable from an Operator Workstation shall be annotated with (FA) after the name of the parameter. This shall include set points, reset schedule parameters, calibration offsets, timer settings, control loop parameters such as gain, integral time constant, sample rates, differentials, etc.
   f. Within the sequence of control, all calculated values that are to be viewable at the Operator Workstation shall be annotated with (rpt) after the name.
   g. All points that shall be subject to manual control from an operator workstation.
   h. A list of all alarm points, a description of the alarm and a description of the alarm criteria.
   i. A list of all variables for which historical trending will be applied, the sample rates and any criteria used to start and stop the historical trending.
11. Binding Map
   a. A list of the device to device data flow. This shall not include the flow of data from devices to the presentation system.
   b. Include:
      1). Description of the variable.
      2). Sending device.
      3). Receiving device.

D. Completion Checklist:
   1. Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
   2. Checklist shall include references to the following additional requirements:
      a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.
      b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.
      c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).

d. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.

e. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.

f. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.

g. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.

h. Schedules for each system/device shall be verified.

i. Testing of BAS to ensure cyber security. Coordinate testing requirements with Owner.

E. Control Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.

1.8 WARRANTY

A. Warranty period shall begin as authorized by the UEM representative in writing. A Certificate of Occupancy does not initiate the control system warranty. Any defects in materials and workmanship arising during this warranty period shall be corrected without cost to the owner.

B. All applicable software as detailed in this specification shall be updated by the BAS Contractor free of charge during the warranty period. This will ensure that all system software will be the most up-to-date software available from the BAS Contractor.

C. Authorization will not be given before the following conditions are met:

1. All verified completion checklists provided to Owner.
2. Completion of all punch list items.
3. Conduction of a preliminary training session for personnel. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings.
4. Completion and distribution of the as-built control drawings, including correction of all items noted by Owner and Engineer after review of the documents.

D. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.

E. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. A telephone number where the service supervisor can be reached at all times shall be provided. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.

F. The system including all hardware and software components shall be warranted for a period of one year when the system performance is deemed satisfactory in whole by UEM. The system parts will be accepted for beneficial use and placed under warranty at that time. A Certificate of Occupancy does not initiate the control system warranty. Any defects in materials and workmanship arising during this warranty period shall be corrected without cost to the Owner.

G. All applicable software as detailed in this specification shall be updated by the EMS/BAS/BSM Contractor free of charge during the warranty period. This will ensure that all system software will be the most up-to-date software available from the EMS/BAS/BSM Contractor.

H. Service personnel shall be qualified to accomplish work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

I. Scheduled Inspections:

1. Two inspections shall be performed prior to warranty expiration and all work required shall be performed. Inspections shall be scheduled 6 months after Owner acceptance and one month prior to end of warranty period.
2. These inspections shall include:
    a. Visual checks and operational tests of equipment.
    b. Clean control system equipment including interior and exterior surfaces.
    c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.
    d. Run system software diagnostics and correct diagnosed problems.
    e. Resolve any previous outstanding problems.
    f. Install software upgrades, patches and fixes. Contractor to provide verification to facility personnel that all upgrades, patches and fixes to be installed have been tested in accordance with site testing and deployment procedures.

J. Scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.

K. Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

L. Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

M. Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected.

N. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.

1. : At the end of the project, the contractor is to supply digital back-up copies of all final complete operating controls programs. These shall be delivered to UEM for archiving purposes.

O. At the end of the warranty period, the Contractor shall provide updated copies of the latest versions of all project record documentation as described in Paragraph 1.10, Record Documents. This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.

1.9 COORDINATION WITH TAB CONTRACTOR

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

B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements.
   1. One (1) physical and one (1) electronic copy of FMS Manuals shall be provided to University of Kentucky by the BAS Contractor at date of completion.

B. Operation and Maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. Descriptions shall include:

C. Facility Management System (FMS) Manuals
   1. FMS manuals are to be split into two parts:
      a. Operation and Maintenance
         1). Index of all control devices
         2). Detailed Data sheets
         3). Detailed Sequence of operations
         4). Detailed Diagrams
            a). System architecture diagram for components within the building annotated with specific location information.
         5). List of recommended maintenance tasks associated with the system, controllers, instruments, operator workstations, data servers, web servers, and web clients.
            a). Define the task.
            b). Recommend a frequency for the task.
            c). Reference the product manual that includes instructions on executing the task.
         6). Licenses, guarantees, and warranty documents for equipment and systems.
         7). System architecture diagram for components within the building annotated with specific location information.
         8). As-built drawing for each control panel
         9). As-built wiring design diagram for each control panel
         10). As-built system flow diagram for each system
         11). Binding map for the building

a). A list of the device to device data flow. This shall not include the flow of data from devices to the presentation system.
b). Include:
c). Description of the variable
d). Sending device
e). Receiving device

12). Product data sheet for each component
13). Troubleshooting guide
14). Repair parts list
15). Calibration instructions
16). Control Contractor's completion checklist
17). Manufacturer representative's name, address, and phone number

b. System Application manuals
1). Detailed Sequence of operations
2). Definitions of all DDCP software programs
3). Flow chart of all DDCP software programs
4). Points list of all hardwired devices
5). A programming section that includes a description of programming language used
6). Full documentation and program description of all separately written programs
a). Operating the system
b). Administering the system
c). Engineering the Operator workstation
d). Application programming
e). Engineering the network
f). Setting up the web server
g). Report creation
h). Graphics creation
i). Data backup & Archiving

1.11 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements.

B. Submit revised shop drawings indicating changes made during Project.

C. Record drawing submittals shall be inclusive of BAS as installed and commissioned.

D. Update control diagrams to include tuning parameters and set points applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation for each system.

E. Include floor plans showing location of control panels and routing of BAS network cabling.

F. List of all IP addresses assigned on IFMS complete with description of device and associated vendor.

G. BACnet systems and devices:
1. Submit finished device addressing documentation.

2. Submit finished hardcopy of device binding database.

H. Provide passwords, if used, for back-up and restore functions for each controller.

I. Software (as installed and commissioned)
   1. All software submittals shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided as part of the BAS.
   2. Submit a copy of all software installed on the servers and workstations. These copies shall be delivered to UEM for archiving purposes.
   3. Submit all licensing information for all software installed on the servers and workstations.
   4. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
   5. Submit all licensing information for all of the software used to execute the project.
   6. All software revisions shall be as installed at the time of the system acceptance.

J. Firmware Files (as installed and commissioned)
   1. All firmware files shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided in the BAS.
   2. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
   3. Submit control listing of firmware version for all firmware that is permanently burned on a chip at the factory.
   4. Submit a copy of all application files that were created during the execution of the project.

K. BACnet Protocol Implementation Conformance Statement
   1. The controls contractor shall include their BACnet PICS and BIBB statements (as described in ASHRAE 135-2001) for their BACnet Interface with their shop drawings. The interface shall comply with the following as a minimum.
   2. Vendor Name: Tridium, Inc.
   3. Product Family: Niagara Framework, including N4 Web Supervisor, JACE 6XX at Release 3.8, JACE 8xxx at release 4.6 or greater using the most current version of JAVA or HTML 5. All control work associated with this project must be fully compatible with this version of Tridium such that all alarms, points, etc. communicate and clear alarms seamlessly with the existing system.
   4. Description: This product family provides bi-directional communication between the Tridium Niagara Framework and a BACnet system operating at BACnet Conformance Class 3, over Ethernet media.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Owner shall retain all rights to software for this project.

B. Use of the software by individuals under contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

C. All project developed software, files and documentation shall become the property of Owner. These include but are not limited to:
   1. Server and Workstation software

2. Application Programming Tools
3. Configuration Tools
4. Addressing Tools
5. Application Files
6. Configuration Files
7. Graphic Files
8. Report Files
9. Graphic Symbol Libraries
10. All Documentation.

PART 2 - PRODUCTS

2.1 CONTROL WIRING

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

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

C. Terminal Blocks:
   1. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

D. Signal and Power Conductors (24 V and Under):
   1. Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3-conductor. Provide isolated instrument grounding system as per manufacturer's recommendations.
   2. Conductors not concealed in raceway shall have UL Listed plenum rated Teflon insulation.
   3. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 - 20 mA circuits as required to generate 1 to 5 volt signals in 24 VDC powered instrument loops.
   4. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).

E. Communication Cable:
   1. Cable not concealed in raceway shall have UL Listed plenum rated insulation.
   2. Floor Level Network Communication Cable (Twisted Pair): Use control system manufacturer's standard communications cable or #22 AWG to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote controllers/devices
   3. Interior LAN Horizontal Communication Cable:
      a. Refer to specification 27 1500 - Communications Horizontal Cabling.
      b. Horizontal copper LAN cable shall meet or exceed all requirements of Category 6 cable as specified in TIA/EIA-568-B.2.

c. BAS Ethernet network Horizontal copper LAN cable shall be yellow.

d. Horizontal copper LAN cable shall be terminated in an eight-position modular Jack with color to match system cable.

e. Horizontal copper LAN cable shall be terminated in a telecommunication room that is on the same floor as the area being served in a 4-pair 100Ω twisted pair modular patch panel with color to match system cable.

f. Horizontal copper LAN cabling shall not exceed 295 ft.

g. Provide minimum of 10' of slack at telecommunication room and 12" of slack at outlet

F. All wiring, conductors and transmission medium shall be in conduit.

1. Minimum conduit size shall be ¾"
2. Size conduit for 75% fill.
   a. Example: for each three conductors in the conduit, room for one additional conductor must be provided.
3. All EMT fittings used on conduit sizes 2 ½" and smaller shall be compression type. No set-screw type fittings are allowed.

G. Transient Voltage Surge Suppression Devices:

1. Devices shall be designed for 120 V power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and C62.45, Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, 75, and 78, and UL 1449 and 1283. Devices shall be labeled for UL 1449.
2. Clamping voltage for 120 V power systems shall be 400 V.
3. Provide visual indicator of when surge device has been used.

H. Uninterruptible Power Supply

1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
2. Provide UPS for backup power for Operator Workstations, Building Level Controllers, Floor Level Controllers and field panels required for control of emergency/standby powered equipment, UPS shall maintain control upon loss of normal power and until emergency/standby power supply is brought on line.
3. Select UPS for minimum of 5 minutes backup time for load connected. This will allow emergency/standby power sources to come on line and provide backup power to emergency/standby powered equipment.
4. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
5. Operating Parameters:
   a. Operating Temperature: 32°F to 104°F
   b. Relative Humidity: 0 to 95% rh, non-condensing
   c. Recharge Time: 8 hours, typical
6. UPS shall have self-diagnostic capability with DO to BAS to allow remote monitoring/alarming of UPS trouble or alarm conditions.

2.2 INPUT/OUTPUT SUMMARY

A. The system as specified shall monitor, control and calculate all of the points and functions as listed in the Input/Output Summary.

2.3 LOCAL CONTROL PANELS

A. Control panels shall meet the following minimum requirements:
   1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
   2. Mechanical Rooms: Control panels located in mechanical or electrical rooms shall comply with NEMA 12 requirements.
   3. Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.

B. 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 **3R** for exterior panels.

C. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.

2.4 NETWORK HARDWARE

A. Ethernet Switches, Routers, and Bridges:
   1. Network hardware shall be provided and configured to form a campus-wide Fast Ethernet (a combination of 100BASE-TX and 100BASE-BX, -FX, and –SX or higher).
   2. Ethernet devices shall be IEEE Std 802.3 which shall function as the center of a distributed-star architecture and shall be "learning" type with spanning tree algorithms per IEEE Std 802.1D. All devices shall have a non-blocking architecture.
   3. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.
   4. Network hardware shall be compatible with the copper and fiber optic cabling installed by the Division 27 contractor. Refer to specifications 27 1300 and 27 1500 for media types.
   5. Switch located in BAS server rack shall be managed type and shall have a minimum of two fiber optic ports.
   6. Switch shall include N.O./N.C. alarm contact for monitoring by BAS.

B. Network Components:
   1. Network components (Racks, enclosures, patch panels, etc.) shall comply with respective sections of specification 27 1100 – Communications Equipment Room Fittings.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, **and wiring** in neat and workmanlike manner.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. All BAS associated 120 VAC power wiring (including all input and output power supplies) shall originate from clearly-marked, BAS-dedicated circuit breakers. All input/output transducers shall be powered from the

same circuit that supplies power to the associated BAS controller. All BAS equipment shall be fused in accordance with manufacturer's recommendations.

E. BAS controllers shall be labeled with the source of electrical power including panel number, circuit breaker number, and room number where electric panel is located.

F. Devices containing mercury are not allowed.

G. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

H. All anchors used for mounting equipment, devices, or panels shall be metal. Plastic anchors are not allowed.

3.2 DELIVERY, STORAGE AND HANDLING

A. Provide factory shipping cartons for each piece of equipment and control device. Maintain cartons while shipping, storage and handling as required to prevent equipment damage and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

3.3 CONTROL WIRING

A. Provide electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with applicable local codes, and latest version of National Electrical Code and NFPA. Refer to Paragraph 1.6.H. for definition of scope of Work.

1. Voltage drops for all low voltage circuits shall be calculated prior to installing low voltage circuits. Voltage drop calculations shall be made available to Engineer on demand.

B. Control panels serving equipment fed by emergency/standby power shall also be served by emergency/standby power. Equipment fed by emergency/standby power is so indicated on mechanical equipment schedules and electrical panelboard schedules. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers, Application Specific Controllers and fume hood controls shall be provided with local UPS power.

C. Where multiple controllers reside in a single control panel, provide a separate disconnect (or fuse) for each controller.

D. Power wiring to control compressors and dryers will be provided by Electrical Contractor. Furnish field-mounted starters to Electrical Contractor for installation and supervise installation.

E. Install control wiring in raceway system per Division 26 – Electrical, except as noted.

1. All 24 VAC or any cabling carrying AC voltage will not be allowed in cable tray. 24 VAC and any other AC voltage cabling will require conduit or raceway separate from data cable raceway.

F. Install control wiring in raceway system per Division 26 – Electrical, except as noted.

1. All 24 VAC or any cabling carrying AC voltage will not be allowed in cable tray. 24 VAC and any other AC voltage cabling will require conduit or raceway separate from data cable raceway.

G. Control wiring shall be installed in raceway or rigid conduit. Cabling connections between control devices and raceway/conduit shall be installed in flexible conduit not more than 6’ in length.

H. Color-code each junction box cover plate as to signal type using 1/2" self-adhesive color dot or enamel spray paint. Use green for low voltage signal wiring, blue for pneumatic tubing, and yellow for line voltage wiring used for signal wiring or dedicated power wiring.

I. Tag each wire termination at control panels, junction boxes, and remote control devices with unique wire ID number.

J. All wiring, conductors and transmission medium shall be in conduit.
   1. Minimum conduit size shall be ¾”
   2. Size conduit for 75% fill.
      a. Example: for each three conductors in the conduit, room for one additional conductor must be provided.
   3. All EMT fittings used on conduit sizes 2 ½” and smaller shall be compression type. No set-screw type fittings are allowed.

K. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.

L. Connect electrical components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

M. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

N. All wiring terminating in a control panel/enclosure shall be landed on terminal strips, with one wire per terminal. All I/O points on a DDC/BAS controller shall be wired to panel-side of terminal strip, including all spare I/O points.

O. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require intrinsic barrier if run in the same path with wiring of other classifications.

P. Follow Control Contractor’s Company standard cabling color codes.

Q. Suggested instrument and control conductor cables and color codes are as follows:

Type	Configuration	Colors	Manufacturer Part No.
120 VAC, 14 AWG	2 Cond., Unshielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Gray PVC	Belden 9411
120 VAC, 14 AWG	3 Cond., Unshielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED	Belden 9495

Type	Configuration	Colors	Manufacturer Part No.
		Jacket - Gray PVC	
24 VAC, 18 AWG	2 Cond., Unshielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 89740
24 VAC, 18 AWG	2 Cond., Unshielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Gray PVC	Belden 9409
Analog Input, 18 AWG	2 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 88760
Analog Input, 18 AWG	2 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Jacket - Black PVC	Belden 1032A
Analog Input, 18 AWG	3 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Red FEP	Belden 88770
Analog Input, 18 AWG	3 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Black PVC	Belden 1036A
Analog Output, 18 AWG	2 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 88760
Analog Output, 18 AWG	2 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Jacket - Black PVC	Belden 1032A
Analog Output, 18 AWG	3 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Red FEP	Belden 88770
Analog Output, 18 AWG	3 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Black PVC	Belden 1036A
Discrete Input, 18 AWG	2 Cond., Unshielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 89740
Discrete Input, 18	2 Cond., Unshielded,	Cond. 1 - BLK	Belden 9409

Type	Configuration	Colors	Manufacturer Part No.
AWG	Non-Plenum Rated	Cond. 2 - RED Jacket - Gray PVC	
Discrete Output, 18 AWG	2 Cond., Unshielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 89740
Discrete Output, 18 AWG	2 Cond., Unshielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Gray PVC	Belden 9409
Discrete Output, 18 AWG	3 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Red FEP	Belden 88770
Discrete Output, 18 AWG	3 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Black PVC	Belden 1036A
General Purpose, 18 AWG	2 Cond., Unshielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Red FEP	Belden 88760
General Purpose, 18 AWG	2 Cond., Unshielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Gray PVC	Belden 9409
General Purpose, 18 AWG	3 Cond., Shielded, Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Red FEP	Belden 88770
General Purpose, 18 AWG	3 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Black PVC	Belden 1036A
Intrinsically Safe Control Cable, 17 AWG	2 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - RED Jacket - Light Blue PVC	Anixter BL0012650
Intrinsically Safe Control Cable, 17 AWG	3 Cond., Shielded, Non-Plenum Rated	Cond. 1 - BLK Cond. 2 - WHT Cond. 3 - RED Jacket - Light Blue PVC	Anixter BL0012651

R. Electric Signal Cables:

1. Analog electric signal cables from electronic transmitters to controllers/receivers and from controllers to other analog devices shall be continuously shielded to reduce effects of EMI on control signals residing on those cables. Electric signal cables to discrete devices typically do not require shielding, but for better noise immunity use twisted/shielded pairs.
2. Shields shall be grounded at power source end only and floated at other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at other points.
3. Provide 250 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 1 - 5 VDC signals or 500 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 2 - 10 VDC signals from 4 - 20 mA control loop powered by 24 VDC power supply.

S. BAS Network Communication Cable:

1. Install special cable connectors in accordance with BAS manufacturer's recommendations.
2. Typically, #22 AWG, but no smaller than #24 AWG, twisted pairs, twisted shielded pairs, coaxial cable, fiber optics or manufacturer's standard cabling for communications between remote control devices and BAS controllers.
3. BAS Network communication cable shall not be spliced.
4. Provide isolated instrument grounding system as necessary per manufacturer's recommendations.

3.4 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.

B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.

C. Label local control panels with respective unique ID numbers in accordance with Section 20 0553 - Mechanical Identification.

D. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.

E. Furnish and install power cabling and conduit for temperature controls panels and equipment from emergency power panels. Each temperature control panel shall be connected to a separate circuit. Conduits shall connect to panels at the locations directed by the Contractor under Division 26. Final connection in the power panels shall be by Temperature Control Contractor in coordination with Division 26 Contractor.

F. Panel Layout:

1. Locate controllers in lower half of panel first and upper half second.
2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
3. Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.
4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.

5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
6. Do not place controller or control devices on enclosure sides.
7. Do not use any control panel as wire or cable pass-through to adjacent panel.

3.5 BAS ETHERNET NETWORK TESTING AND BENCHMARKING

A. Test and document connectivity, latency, and integrity of network from each switch to each BAS controller and BAS server switch and from switch-to-switch.
   1. Latency between any ports shall be equal to or less than 1 millisecond.
   2. Packet loss shall be less than 0.5% between any ports when tested with frame sizes between 64 and 1518 frames for duration of 60 seconds.

B. Test and document all telecommunication protection/security techniques employed on system including access control into BAS Ethernet network from other building networks and access control to other building networks from BAS Ethernet network. Coordinate testing procedures with Owner.

3.6 ADJUSTMENT AND COMPLETION CHECKLIST

A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract. Include signed and dated, completed checklist in Operation and Maintenance Manuals.

B. Upon completion of Work but before final acceptance of systems, Engineer or Owner's representative will verify performance of control loops. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. Corrective modifications made by Control Contractor during warranty period shall be incorporated and updated in Operation and Maintenance Manuals.

C. After final acceptance of system, Contractor shall work with Owner to remove all existing user names and passwords for all software and hardware used on project and create new user names and passwords as required.

D. Upon completion of the installation, the BAS Contractor shall start up the system and perform all necessary testing and debugging operations. An acceptance test in the presence of the Owner's representative shall be performed. The vendor shall check all sensors that exhibit any problems or faulty reading. When the system performance is deemed satisfactory in whole by UEM, the system parts will be accepted for beneficial use and placed under warranty. The BAS Contractor is to be available for system commissioning at the end of the installation when requested by the Engineer and/or Owner. The contractor is to also be available for seasonal commissioning for the other seasons beyond the initial commissioning.

E. This Contractor shall work with the Owner (UEM), who is developing the graphics, to ensure that all points report, function and alarm as required on the BACnet head-end system. The Contractor will also work with the Project Manager or CNS/MCIS to obtain all necessary IP’s and Ethernet drops needed for BACnet panel. The Owner (UEM) will assign all BACnet/IP instance numbers and all BACnet/MSTP network numbers for use by the Contractor. All BACnet/IP devices will report directly to the head-end system.

F. After completion of the installation, the automatic temperature control manufacturer shall regulate and adjust all thermostats, control valves, motors, and other equipment provided under his contract and shall place them in complete operating condition, subject to approval by the Engineer and Owner.

G. This shall include but not be limited to "tuning" of all control systems. Systems shall be tuned for decaying wave response and minimal overshoot of setpoint. Contractor is to not leave any system in an Auto Tune mode.

H. Room temperature controls shall have one temperature setpoint with less than a 0.5˚F between calculated heating and cooling temperatures.

I. This Contractor shall work with Balancing Contractor to provide verification of CFM reading from the DDC terminal unit controllers.

J. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

K. After completion of installation, perform the following:
   1. Installation.
      a. Check proper installation and connection of each control device.
      b. Verify electric power.
      c. Verify each sensor and actuator connection to field computer.
   2. Field Computer Operation.
      a. Point Test.
      b. - check of wiring of each sensor and actuator end-to-end
      c. - verify calibration of each sensor.
      d. - verify manual operation of each actuator.
   3. Local loop control.
      a. - bring each local loop under control.
      b. - check response to upset, change in setpoint.
      c. - check full and partial load operation.
   4. Supervisory functions.
      a. - verify time clock schedules.
      b. - verify reset control.
   5. Verify communication with each field device.
      a. - perform end-to-end sensor and actuator checks.
      b. - verify that the database is correct.
   6. Test other software.
      a. Trend Logging.
      b. Report Generation.
      c. Remote Access.
      d. System Documentation.

L. Verify proper operation of every control point in the presence of the Engineer. Include point-by-point checkout.

M. The control manufacturer shall provide a period of free service extending through one complete heating season and one complete cooling season, after acceptance of the control system, and shall report the condition of the control equipment to the Owner and the Architect.

N. UEM will be performing their own complete point by point evaluation as part of this project, independently of the commissioning activity. This will occur during the warranty period of the project.

3.7 OWNER TRAINING

A. Provide full time BAS operator to run system after systems have been started and are regularly used until Owner has completed on-site training specified.

B. Provide minimum of **24** hours of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner. Scheduling of training session(s) will be established by Owner. Portions of training may be performed before system is completely operational, but no sooner than one month before system is planned to be fully operational. Final training session shall be held after systems are complete including all graphics programming.

C. *The BAS Contractor shall provide two copies of an electronic version of the operator's manual describing all operating and routine procedures to be used with the system. This user's manual should contain subjects such as: standard operation, error message explanations, software usage, commands, system troubleshooting, etc. The Contractor shall also provide wiring schematics for all system components.*

D. *The BAS Contractor shall instruct the Owner's designated representatives in these procedures during the start up and test period. The duration of the instruction period shall be no less than four (4) hours during two 2 hour sessions. (Number of hours may be adjusted to a max of 40 dependent upon the size and scope of project. For larger projects, training vouchers for instructional training at the manufacturer's facilities may be requested in lieu of on-site training.) These instructions are to be conducted during normal working hours at the Owner's convenience and are to be prearranged with the Owner. The owner can request this training any time within the one year warranty period and may request any number of classes adding up to the total number of hours. The contractor shall provide an hourly unit price for additional on-site training.*

E. *The instructions shall consist of both hands on at the job site and classroom training at a classroom location on the University of Kentucky campus coordinated with the Project Manager and UEM.*

F. Course content shall include, but not be limited to, the following topics:
   1. Upon completion, the attendees shall be able to operate the system and implement system changes including start up, boot load, add point to the data base, enter messages, and down line load field units.
   2. Prior to the scheduling of the sessions, an agenda outlining the training topics must be submitted for approval. Agenda items shall include, but not be limited to, the following topics:
      a. Explanation of control sequences. Include which sensors are used and how output device operates.
      b. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
         1). Walk-through of project to identify controller locations and general routing of network cabling.
      c. Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.
      d. Programming Application Specific Controllers
         1). Backing up and Restoring Application Specific Programming
         2). Adding/Deleting/Editing points on Application Specific controllers
         3). Troubleshooting Application Specific controllers (inputs/outputs/logic/master – slave relationships/bus issues)
      e. Programming Building Specific Controllers
         1). Backing up and Restoring Building Specific Controllers Programming

2). Adding/Deleting/Editing points on Building Specific Controllers controllers

3). Troubleshooting Building Specific Controllers controllers (inputs/outputs/logic/network issues)

f. How to use tools and cables

G. Course content shall include, but not be limited to, the following topics:

1. Review of operation of operator's workstation; include hardware (PC's, printers, etc.).
2. Review of operator's workstation software using specific examples of operating hardware.
3. Review of portable operator's workstation software using specific examples of operating hardware.
4. Any additional item(s) specifically requested by Owner.

H. Provide listing of regularly scheduled factory classroom training sessions concerning advanced topics covering proper operation and maintenance of control systems, sensing, monitoring and control equipment. Additional classes travel and lodging will be arranged and paid by Owner.

I. Provide minimum of **8** hours of additional on-site training to Owner's Representatives, 6 months after initial training is completed.

J. Scheduling of training session(s) will be established by Owner.

END OF SECTION

Qualification Form	
Brief resume of **key** persons, specialists, and individual consultants anticipated for this project:	
a. Name & Title:	b. Project Assignment:
c. Name of Firm with which Associated:	d. Years of Experience: With this Firm_____ Other firms_____
e. Education: Degree(s)/Year/Specialization	f. Responsibility Level Proposed for this Project:
g. Other experience and qualifications relevant to the proposed project (include training courses/certifications):	

Recent Relevant Experience (see example below) ▪ Company, Location - Name of Specific Project, Facility - Description of Work and Responsibilities	**Qualifications**

SECTION 23 0902 CONTROL VALVES AND DAMPERS

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

E. Section 23 3600 - Air Terminal Devices

F. Section 23-3614 – Pressure Relationship, Temperature and Airflow Control System

G. Section 23-8413 – Humidification Equipment

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 GENERAL

A. Devices containing mercury are not allowed.

1.4 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.

1.5 VALVE SELECTION AND SIZING

A. General:
1. Select control valves to meet their intended service without cavitation. Provide cavitation calculations for modulating globe control valves over 250°Fand all modulating butterfly valves over 60°F.
2. Select control valves and actuators for 100% shut-off against system maximum differential pressure.
3. Valve body ratings indicated in Part 2 are minimum required. Valve body, trim and packing selected shall be designed to withstand maximum pressure and temperature encountered in system.
4. Submit engineering calculations for sizing modulating control valves unless valves are scheduled. Control valves serving terminal devices may be sized based on flow ranges for each pump system.
5. Shut-off and 2-position valves shall be full pipe size.
6. Calculations for sizing modulating valves shall be based on actual characteristics of equipment and system in which valves are installed. Valve calculations shall include information such as pump head or available pressure.
7. Control Contractor is responsible for obtaining adequate system information necessary for sizing.

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

C. Water Valves:
1. Select modulating control valves to provide 3-5 psi pressure drop at design flow rate with differential pressure less than 20 psi, and pressure drop equal to 25% of total pressure drop with differential pressure equal to or greater than 20 psi.
2. Design criteria for sizing modulating valves shall be based on 2 port, normally open, equal percentage valves unless otherwise specified. Select heating and cooling coil control valves of major equipment including air handling units for minimum of 30-50% of equipment sub-circuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balancing valve.
3. Select control valves based upon pressure drop calculations and Cv values at 100% stroke.
4. Size 3-way mixing or diverting valves not directly associated with pump subcircuit for 3-5 psi pressure drop.
5. Subcircuit is defined as branch supply and return piping to terminal device, including valve, coil, control valve, and balancing valve.

D. Steam Valves
1. Modulating straight-through globe type valves with linear characteristics for 90% of closing stroke and equal-percentage for final 10%.
2. For steam inlet pressure less than 15 psig, size valves for pressure drop equal to 80% of gauge inlet steam pressure. ($\Delta P = 0.8$ x Inlet Gauge Pressure).
3. For steam inlet pressure of 15 psig or greater, size valves for pressure drop equal to 42% of absolute inlet steam pressure. ($\Delta P = 0.42$ x Inlet Absolute Pressure).

1.6 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 VALVES

A. General:
1. If control valves are not scheduled, refer to Part 1 of this Section for sizing criteria.
2. Use 2 or 3 port normally open globe type control valves with equal percentage contoured throttling plugs for steam and water applications, except as otherwise noted.
3. Butterfly valves may be used for water system control valves 5" and larger provided that valves meet pressure and temperature requirements. High performance butterfly valves shall be used for modulating applications. General purpose butterfly valves may be used for 2 position control.

B. Globe Valves (Commercial Grade):
1. Manufacturers: Honeywell, Johnson Controls, Siemens Building Technologies, or TAC
2. Valves shall be bronze or brass body, threaded ends for steel piping, solder ends for copper piping, 150 psi rating for 2" and smaller; iron body, bronze mounted, flanged, 125 psi rating for 2-1/2" and larger.
3. Valves shall have stainless steel stems, spring-loaded Teflon packing, with replaceable stem/plug and packing kits.

C. Characterized Ball Valves:
1. Belimo, Valve Solutions Inc., Bray Controls, Neles Controls or approved equal
2. Provide two-way or three-way modulating control valves as required.
3. Valves shall be ball-type valves with V-notch, segmented ball or characterizing disks for equal percentage flow response. Characterizing disks shall be securely fastened by a keyed ring or other securing device to prevent the disk from movement during operation.
4. Valves shall be forged brass body, NPT threaded ends, 150 psi rating for 2" and smaller. Valve bodies 2-1/2" and larger shall be carbon steel or cast iron.

5. Valves shall be furnished with stainless steel ball and stem with fiberglass reinforced Teflon (RTFE) seats and Viton, EPDM or RTFE O-rings and seals.
6. Actuators shall be spring return type for valves requiring fail position; floating control, or fail last position type for areas such as animal rooms, offices or conference rooms.
7. Actuators for major equipment such as air handling units, heating hot water or chilled water shall be fail-in-place, fail open, or fail closed depending upon service requirements. Size actuators to achieve system shutoff pressures.
8. Terminal control valves near the end of the reheat supply lines on each floor shall be 3-way diverting type valves to provide minimum flow through the supply mains.

D. General Purpose Butterfly Valves:
1. Refer to Section 23 2118 - Valves. Refer to Damper and Valve Actuators in this Section for valve actuators.

E. High Performance Butterfly Valves:
1. Manufacturers: DeZurik, Xomox, Jamesbury, Posi-Seal, Bray/McCannalok or Fisher
2. Carbon steel body, lugged style, ANSI Class 150, adjustable PTFE packing, PTFE seat with suitable metal back-up ring, upper and lower shaft thrust bearings, 316 stainless steel one piece shaft and 316 stainless steel disc with offset shaft/disc design.
3. Normal and dead end (without downstream flanging) pressure rating shall be 275 psi.
4. Provide pneumatic actuator and positioner. Provide limit switches as required.
5. Valves and actuators shall be manufactured by valve manufacturer. Valve assembly including actuator, positioner and limit switches if used shall be assembled by valve manufacturer.

F. Terminal Control Valves With Characterizing Disks (Reheat or Chilled Water):
1. Belimo, Johnson Controls, Siemens Building Technologies, Honeywell, TAC or approved equal
2. Provide two-way or three-way modulating control valves as required.
3. Valves shall be ball-type valves with characterizing disks for equal percentage flow response. Characterizing disks shall be securely fastened by a keyed ring to prevent the disk from movement.
4. Valves shall be forged bass body with nickel plating, NPT threaded ends, 150 psig rating for 2" and smaller.
5. Valves shall be furnished with stainless steel ball and stem, and fiberglass reinforced Teflon seats and seals.
6. Terminal control valves near the end of the reheat supply lines on each floor shall be 3-way diverting type valves to provide minimum flow through the supply mains.
7. Actuators shall be spring return type for valves requiring fail position, floating control with fail last position type for areas such as animal rooms, offices or conference rooms.
8. Manufacturer shall warranty components for period of 5 yrs from date of production, with first 2 yrs unconditional.

G. Terminal Control Valves – Globe Type:
1. Manufacturers: Siemens Building Technologies, Johnson Controls, Honeywell, Invensys Building Systems or approved equal.
2. Valves shall be globe type forged brass or bronze with threaded body connections. Valves shall be provided with stainless steel stems and trim. Packing shall be Ethylene Propylene Rubber or Teflon.
3. Provide 3-way mixing control valves at the last 2 reheat coils at the end of each supply main on each floor to provide minimum flow path.

4. Unless otherwise noted, provide fail open pneumatic or electric actuators as identified in control sequences and shown on project drawings.

2.2 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 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. Actuators are to be electric type unless otherwise noted. Provide damper position switches when damper position is required by control sequences.
5. AMCA Leakage Classification of Control Dampers

Class	**Static Pressure kPa (Inches Water Column)**			
	1	4	8	12
	Leakage Rate L/s/m^2(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 D-1200/D-1300 (Double Piece)
   b. Honeywell D642/D643
   c. Ruskin CD50/CD60
2. Damper frames shall be minimum of 14 ga extruded aluminum. Blades shall be minimum of 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.

C. Exhaust System Outside Air Bypass Dampers:

1. Manufacturers: Ruskin Model CD80AF2 or American Warming and Ventilating Model VC-423
2. Galvanized steel construction, suitable for maximum temperature 250°F, approach velocity 6000 fpm and differential pressure of 13.5" WC.
3. Air foil blade design, 16 ga minimum and 12" maximum width.
4. Furnish with flexible jamb seals, EPDM, silicone or neoprene blade seals and pneumatic damper actuators with pilot positioners.
5. Damper actuators shall be fail-open pneumatic type with pilot positioners.
6. Damper actuators shall be fail-open, electric 120 V AC, heavy duty industrial quality similar to Valvcon, Rotork, Limitorque or Automax.

D. SMOKE DAMPERS

1. Manufacturers: Air Balance, Johnson Controls, Ruskin or Vent Products.
2. Dampers shall be leakage rated at no higher than Leakage Class I (4 cfm/ft2 at 1" WG and 8 cfm/ft2 at 4" WG) under UL 555S at temperature category 250°F. Furnish dampers with factory-mounted, caulked sleeve and actuator assemblies. Damper shall have 16 gauge or heavier frame with air foil-shaped blades, rated to minimum 4" WG in closed position and to 2000 fpm in open position.
3. Actuator assemblies shall be installed outside airstream, linked to damper for fail (normally) closed operation. Actuator shall be capable of closing damper at pressures encountered in system.
4. Size smoke dampers as close as possible to duct size, but in no case is damper size to be less than duct size.
5. Dampers shall fully open in 15 seconds or less and fully close in not more than 15 seconds and not less than 7 seconds when activated.
6. Electric actuators shall be non-stall type.

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.

PART 3 - EXECUTION

3.1 CONTROL VALVES

A. Furnish control valves as shown on drawings and/or as required to perform control sequences specified.

B. Control valves furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

C. Increaser and decreaser fittings required to facilitate valve installations shall be provided by Mechanical Contractor.

3.2 CONTROL DAMPERS

A. Furnish control dampers actuators 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.

3.3 SMOKE DAMPERS

A. Refer to Section 23 3314 - Ductwork Specialties

B. Furnish smoke dampers as shown on drawings.

3.4 ACTUATORS

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. Where sequencing of valves or dampers is required for pneumatic systems, such sequencing shall be accomplished by spring ranges adequate for applications to avoid both overlap of operation and simultaneous use of heating and cooling.

C. Provide pilot positioners for all sequenced devices, and devices which require adjustable operating speeds.

D. Provide pilot positioners for pneumatic modulating outside and return air dampers and fan volume control devices such as fan inlet dampers where used.

E. Provide pilot positioners for pneumatic modulating valve and damper actuators where torque required by controlled devices exceeds 50% of torque capacity of operator.

F. 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.

G. Provide speed control valves for On/Off actuators for adjustment of actuator speed to prevent water hammer or excessive stress on large valves and dampers.

H. 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.

I. Provide single actuator on damper section not exceeding torque capacity of actuator.

J. 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.

K. 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.).

L. Calibrate position feedback potentiometers, where specified, with range and gain factors as required for proper operation per manufacturer's recommendations.

M. Integral actuator end switches or feedback potentiometers shall not be used. Provide separate end switches/feedback potentiometers that provide actual damper/valve position.

1. Integral actuator end switches or feedback potentiometers can be used if damper or valve shaft is keyed or directly affixed to the actuator such that the shaft cannot slip and provide false position. U-clamp type actuator mounting always requires separate end switches/feedback potentiometers.

END OF SECTION

SECTION 23 0903 CONTROL INSTRUMENTATION

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 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 GENERAL

A. Devices containing mercury are not allowed.

1.4 SUBMITTALS

A. Devices shall be indexed by bill of material for each system as detailed in Section 23 0901 - Control Systems Integration.

B. 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.

C. 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.

1.5 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. 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.

B. 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.

D. Control Panels
   1. Panelboard shall contain all instruments and accessories. Provide each item of equipment with an engraved nameplate. Panelboard shall be wall mounted or stand mounted and shall be completely enclosed.
   2. As far as is practical, the control components for each system shall be grouped. Provide each group of components with identification.
   3. The entire panelboard shall be pre wired and brought to a main terminal strip. All relays, switches, etc., shall be installed, furnished and wired on panelboard. Clearly mark each terminal strip as to which wire from which component is to be connected.
   4. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.
   5. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
   6. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
   7. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:
   1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
   2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
   3. Accuracy of devices shall be ± 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 custom color “bright white”.

C. Temperature Switches (Aquastats):
1. Electric 2-position type with strap-on or immersion temperature sensing element. Switch contacts close on increasing temperature to provide start signal for unit heaters, cabinet unit heaters and open on high limit control for heating hot water heat exchangers.
2. Sensing element shall be set for 100°F (FA) for unit heater control. For setpoints to aquastats for hot water heat exchangers, refer to control sequences for each hot water system. Provide screw-type terminals in NEMA 12 switch enclosure for field mounting at unit heaters.

D. 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.

E. 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.

F. 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. 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%

G. Level Switches:
1. Manufacturers: Drexelbrook, Magnetrol, Endress and Hauser or Dwyer
2. Radio Frequency (RF) type continuous level probe with multiple adjustable setpoints and SPDT snap action contacts to meet intended use. Probe shall have probe shielding to reject build up of conductive, sticky or viscous material. Probe length shall match vessel dimensions to measure within 6" of bottom.
3. Provide probe brace every 4 ft if probe length exceeds 6 ft, and not installed in stilling well.
   a. Supply Voltage: 120 VAC/60 Hz
   b. Fail Safe: Low Level output on instrument failure

c. Ambient Temperature Limits: -40 to 160°F
d. Minimum Enclosure Rating: NEMA 4
e. Transmitter Mounting: Remote
f. Performance:
   1). Accuracy: ± 2% nominal
   2). Linearity: ± 1% nominal
   3). Repeatability: ± 1% nominal
   4). Response Time: 20 milliseconds
   5). Ambient Temperature Effect: 2% per 100°F max.
   6). Voltage Variation Effect: ± 0.2% maximum per 10 V change

H. Time Switches (Time Clocks):
1. Manufacturers: Invensys Paragon, Intermatic, Kessler-Ellis Products, Automatic Timing and Controls or Tork.
2. Programmable electronic clock type consisting of electronic clock, LED or LCD display, user interface keypad, and multiple normally open/fail close contacts. Time clocks shall be programmable for up to 8 start/stops per day for each 7 day period.
3. Provide each time clock with battery that will maintain programming schedule for up to 8 hours upon electric power failure and shall return to its programmed position after re-start.

I. E-P Switches (Solenoid Valves):
1. Manufacturers: Asco, Johnson Controls, Siemens Building Technologies, TAC, Kele & Associates or MAC Valves
2. E-P switches shall provide control air for operation of fan isolation dampers, smoke or smoke/fire dampers, or other On/Off dampers. Line voltage actuators shall be Class "H" (high temperature) and listed by UL or CSA.
   a. Valve Body: Brass or bronze
   b. Valve Type: 2-way or 3-way
   c. Operating Voltage: 24 VDC, 24 VAC, 120 VAC or as specified
   d. Operating Temperature: 32 to 104°F
   e. Operating Pressure: Greater than maximum supply pressure
   f. Pipe Size: 1/4" NPT
   g. Enclosure Rating: NEMA 4 (locally mounted), NEMA 1 (Panel Mounted)
   h. Conduit Connection: 1/2"

J. 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

K. 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

L. 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.

M. Moisture Detector:
1. Manufacturers: Raychem Corp. or approved alternate.
   a. Moisture detector shall alarm in the event of water or other conductive liquid present on floors or areas damage may occur to. Moisture detectors shall be used in but not limited to mechanical equipment rooms, computer rooms or other spaces where liquid leakage may cause damage to equipment in the space.
2. Alarm Module: Raychem Model TTA-1 or equal.
   a. Supply Voltage: 120/240 VAC, 60 Hz
   b. Power Consumption: 14 VA
   c. Temperature Rating: 32°F to 105°F (0°C to 40°C)
   d. Sensing Cable: Raychem Trace Tek® Series
   e. Max. Sensing Cable Length: 50 ft. (15 m)
   f. Relays Contacts:
      1). Type: 4PDT
      2). Rating: 3A at 120 VAC/28 VDC
      3). Audible Alarm: 95 decibels
      4). Enclosure Rating: NEMA 12 (Optional NEMA 4X)
3. Sensing Cable: Raychem Model TT1000 or equal.
   a. Sensing Fluid: Water
   b. Cable Characteristics:
      1). Cable Diameter: 0.24 in. (6.0 mm) nominal
      2). Continuity/signal wires: 2 x 26 AWG with fluoropolymer insulation
      3). Sensing Wires 2 x 30 AWG with conductive fluoropolymer jacket
      4). Max. Cable Length: 50 ft.
      5). Max. Cable weight 2.3 lbs.
      6). Max. Operating Temp. 174°F (75°C)
   c. Sensitivity length: 2 inches maximum at any point along sensing cable.
   d. Drying time: Cable dries and resets within 15 seconds of removal from standing water.
4. Accessories:
   a. Modular Leader Cable: Non-conductive cable for connecting Sensing Cable to the Alarm Module.

b. Modular End Termination: Required for Sensing Cable operation.

c. Hold Down Clips: For anchoring the Sensing Cable to floor, bottom of trough or wall.

5. Mount Alarm Module near area to be monitored at approximately 5 feet above finished floor. Run Modular Leader Cable through conduit to location where it connects to the Sensing Cable. In mechanical equipment rooms or electrical equipment rooms, specify NEMA 4X enclosures for the Alarm Module. In computer rooms or other environmentally controlled area a NEMA 12 enclosure may be used for the Alarm Module.

N. Drain Pipe Moisture Detector:

1. Manufacturers: Honeywell 470-12 or approved alternate.
   a. Moisture detector shall alarm in the event of water flowing through drain pipe. Moisture detectors shall be provided with two sensitivity settings.
   b. Supply Voltage: 12 VDC
   c. Power Consumption: 1 mA
   d. Relay Rating: 5 A
   e. Alarm Output: SPDT Form C Contact

2.4 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:

1. Sensors shall be platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/□C
   b. Accuracy: ± .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 65.5150°F, and 0.5°F between -20°F and 212°F.
1. Unless otherwise stated, space sensor cover shall be brushed aluminum or brushed nickel.
2. Provide visible setpoint, set point adjustment, and space temperature indication.
3. Unless otherwise stated, space thermostat covers shall be custom color “bright white”.
4. As indicated on mechanical plans, provide button type temperature sensor (for hallways).

B. Duct Mounted or Insertion Temperature Sensors:

1. Platinum RTD type, with the following minimum performance:
   a. Temperature Coefficient: 0.00385 ohm/ohm/°C
   b. Accuracy: ± .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. Standard lengths to be 5.5”, 11.5” and 17.5”. Other lengths will be at owner’s written approval.

4. 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. Glass encapsulated element unless otherwise approved.
5. 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 576in^2. Mount averaging sensor across duct area in a "Z" pattern using mounting clips specific for averaging temperature sensor probes.
6. 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.

C. Direct Insertion Temperature Sensors:
1. Sensor assembly shall be direct insertion, suitable for use with water systems, 150 lb class, minimum rating.
2. Sensor shall be platinum wound RTD, minimum accuracy of ± 0.06% at 32°F.
3. Sheath diameter shall not exceed 5/16". Length shall be such that sheath, containing sensor, projects into process fluid from 2" to 2.5" beyond pipe wall when installed. Material to be 304 or 316 stainless steel. Process coupling to be 3/8" or 1/2" NPT.
4. Connection head to be NEMA 4, cast iron, with screw on cap. Provide internal termination for RTD and wire connection. Conduit connection shall be 1/2" NPT.
5. Provide hot tap assembly and extension. Material to be 304 or 316 stainless steel. Support hot tap at minimum of 2 points to eliminate vibration. Extension shall exceed insulation thickness by 1".
6. Refer to Section 25 3003 - Process Instrumentation Device Specifications.

D. RTD Temperature Sensor/Transmitters:
1. Manufacturers: Rosemount, Burns, Minco Products, Weed or Pyromation
2. Transmitters shall provide 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter and compatible with DDC equipment.
   a. These shall be 100O platinum RTD type temperature instruments for process immersion or air duct mounting
   b. Operating Temperature: -20 to +180°F
   c. Power Supply Voltage: 13 to 35 VDC unregulated
   d. Accuracy or Output Error: 0.1% of span of sensor and transmitter combination
   e. Temperature Coefficient: 0.00385 ohm/ohm/°C
   f. Thermowells: By same manufacturer as Sensor/Transmitter or approved alternate.
3. Provide local temperature indicator with 3 LCD digital readout.

E. Space Humidity Sensors/Transmitters:
1. Manufacturers: General Eastern, Automation Components Inc., Veris Industries, Hy-Cal (Honeywell), Rotronic or Vaisala
2. Space humidity sensors shall be wall mount type covers shall be custom color "bright white" to match room temperature sensors.
3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance:
   a. Accuracy: ± 2% rh at 25°C over range of 20-95% rh including hysteresis, linearity and repeatability
   b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F

c.	Sensitivity:	0.1% rh
d.	Repeatability:	0.5% rh
e.	Hysteresis:	Less than 1%
f.	Long Term Stability:	Less than 1% rh drift per year
g.	Adjustment:	± 20% rh zero, non-interactive
		± 10% rh span, non-interactive
h.	Operating Range:	0-99% rh, non-condensing, sensor
		0-95% rh, non-condensing, electronics
i.	Output:	4-20 mA, 0-100% linear, proportional
j.	Power:	12-36 VDC

F. Duct Mounted Humidity Sensors/Transmitters:

1. Manufacturers: General Eastern, Automation Components Inc., Versis Industries, Minco, Rotronic or Vaisala
2. Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.

a.	Accuracy:	± 2% rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
b.	Temperature Effect:	Less than 0.06% per °F at baseline of 68°F.
c.	Sensitivity:	0.1% rh
d.	Repeatability:	0.5% rh
e.	Hysteresis:	Less than 1%
f.	Long Term Stability:	Less than 1% drift per year
g.	Adjustment:	± 20% rh zero, non-interactive
		± 10% rh span, non-interactive
h.	Operating Range:	0-99% rh, non-condensing, sensor
		0-95% rh, non-condensing, electronics
i.	Output:	4-20 mA, 0-100% linear, proportional
j.	Power:	12-36 VDC

G. Combination Temperature/Humidity Transmitter:

1. Manufacturers: Automation Components Inc., Veris Industries, Vaisala, Minco or General Eastern
2. Combination Temperature and Humidity sensor/transmitter shall meet the following minimum requirements:
3. Temperature:

a.	Temperature Sensor:	100 or 1000 Ohm Pt RTD
b.	Temperature Coefficient:	.00385 ohm/ohm/°C
c.	Accuracy:	± .54°F + (0.005 X T) (Class B)
d.	Accuracy:	± .27°F + (0.005 X T) (Class A)
		T = Temperature of interest
e.	Operating Range:	-10 to 160°F
f.	Supply Voltage:	18 to 36 VDC / VAC
g.	Output Ranges:	2-wire, 4 to 20 mA or 3-wire, 0 to 5, 0 to 10 VDC or 4 to 20 mA (24 VAC)

4. Humidity:

a. Temperature Compensated: Full range of rh signal
b. Response Time: 30 seconds for 63% step
c. Accuracy Range: ±2% rh between 20 to 95% rh Span (including hysteresis, linearity repeatability).
d. Sensing Element: Resistance or Capacitance humidity sensor
e. Operating rh Range: 0 to 100% rh(non-condensing)
f. Supply Voltage: 24 VDC (current or voltage output) 24 VAC (contact factory)
g. Output Ranges: 4 to 20mA, 0 to 5V, 0 to 10V
h. Long Term Stability: Less than 2% rh drift per year

5. Enclosure shall be made of ABS Plastic or equivalent and include an optional LCD display on face of enclosure.
6. Optional LCD readout shall be capable of °C or °F operation with an adjustable display toggle switch to change from temperature to humidity display. Unit shall include capability of temperature and humidity setpoint value display during adjustment.

H. Dew Point Temperature Transmitter:
1. Manufacturers: General Eastern, Kele & Associates or Vaisala
2. Microprocessor type primary dew point temperature measurement using platinum RTD, 4 wire, 100 ohm temperature sensing element with 4-20 mA transmitter.
a. Accuracy: ± 1°F
b. Repeatability: ± 0.1°F
c. Hysteresis: None
d. Sensor Range: -10°F to +140°F dew point
32°F to 140°F ambient
3. Unit shall be selected for proper application (wall or duct mounted).

I. 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.

J. Space Pressure Monitoring System:

1. Manufacturers: Tek-Air Systems, TSI, Siemens Building Technologies, or approved equal
2. Provide directional pressure monitoring system for clean rooms, isolation rooms. Biosafety research labs and hospital rooms. System shall include ultra-low differential pressure transmitter including thermal mass airflow sensor, two space pressure probes, room display for visual monitoring of space pressurization and LCD readout of space differential pressure.
3. Space pressure monitoring system shall have the following characteristics:
   a. Accuracy: ± 2% of set range.
   b. Pressure Range: 0.100 to -0.100" WC, full scale range, adjustable to ± 0.001, ± 0.005, to 0.010 or 0.10" WC.
   c. Analog Resolution: 0.0001" WC.
   d. Digital Resolution: ± 0.00005" WC.
   e. Output: 4-20 mA DC, self-powered, 5000 ohm load max.
   f. Power Supply: 24 VAC =/- 4 VAC, <10 VA.
   g. Communications: RS-485, RS-232, BACnet, Ethernet or LonWorks.

K. Space Pressure Differential Transmitter:

1. Provide directional mass flow transmitter installed in 2" Schedule 40 black steel pipe between spaces to measure relative velocity created by pressure difference. Provide algorithm in software to convert air velocity to pressure differential (Delta $P = C (V/4005)^2$). Field determine coefficient C by calibrated measurement.
2. Air velocity transmitter shall be equal to Omega FMA-900 Series with the following characteristics:
   a. Accuracy: ± 1.5% full scale, ± 0.5% reading
   b. Repeatability: ± 0.2% of full scale
   c. Probe Temperature Range: -40°F to 250°F
   d. Pressure Range: 150 psig, max
   e. Response Time: 400 msec. to within 63% of final value
   f. Output Signal: 4-20 mA
   g. Accessories: Compression Fittings - Omega 55 LK with Teflon Ferrules.

L. Current Transformers:

1. Manufacturers: General Electric, Square D, Kele & Associates, N-K Technologies or Veris Industries
2. Alternating current transformers shall conform to latest applicable Standards including AEIC, EEI-NEMA, Standards for Instrument Transformers (MSJ-11) and ANSI Standard C57.13 for instrument transformers.
   a. Rated Voltage: 480 V
   b. Insulation Class: 600 V
   c. Basic Impulse Level: 60 Hz
   d. Short Time Current Rating: 100% (1 second)
   e. Accuracy Class: 0.3
   f. Continuous Current Rating: 150%

M. 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

N. 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)

O. Space CO2 Sensors
   1. Manufacturers: Vaisala, Automation Components Inc., Toxalert, or approved alternate.
   2. Provide Carbon Dioxide Monitor as listed below. The system shall be a complete package with integral sensor, monitor, alarm contacts, local indication of current measured value for sensor.
      a. Gas to be Detected: Carbon Dioxide (CO2)
      b. Power Requirements: 24 VAC, 50/60 Hz, 50 VA
      c. Signal Input: Integral Sensor
      d. Signal Output: 4-20 mA DC or 0-10 VDC
      e. Alarm Relays: 1 Amps, 120 VAC, Form C
      f. Range: 0-2000 ppm
      g. Alarm Setpoint: Field Adjustable, Factory set at 1000 ppm
      h. Sensor Infrared CO2 Sensor
      i. Mounting: Wall-mounted
   3. Provide local display for continuous reading of CO_2 levels. Data shall be recorded on system with DDC to the zone level.
   4. Unit shall have adjustable set points and self-test diagnostics.
   5. Certified by manufacturer to require calibration no more frequently than once every 5 years. Provide 120 VAC to 24 VAC transformer adjacent to Air Quality Monitor or provide 24 VAC from Temperature Control Panel nearest Air Quality Monitor.
   6. Sensors shall be wall mount type covers shall be custom color “bright white” to match room temperature sensors.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, wiring and air piping in neat and workmanlike manner and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.

B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Owner and Engineer for approval prior to installation.

3.2 GENERAL INSTRUMENTATION

A. Pressure Gauges (Pressure Indicators):

1. Install pressure gauge for indication of supply and control pressure in pneumatic systems at output of controllers, I/P transducers, electric air solenoid valves, pressure switches and other points where visible indication of air pressure is required for operating and maintenance purposes.
2. Provide test port for quick connection of test gauges at valve, damper motor and other actuator branch lines.
3. Pressure gauge tappings in piping will be provided by Mechanical Contractor.

B. Thermometers (Temperature Indicators):

1. Install thermometers at each point of temperature transmission and control, except for those that are indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft of line of sight). Provide remote bulb thermometers with readout indicators mounted within 3 ft of line of sight whenever sensing point is more than 3 ft from line of sight.
2. Thermometer wells in piping will be installed by Mechanical Contractor.

C. 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.

D. General Instrumentation at Local Control Panels:

1. Provide record control drawings of systems served by each local panel, in location adjacent to or inside of panel cover. Provide protective cover for drawing.

3.3 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Temperature Sensors:

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

4. Space sensors located on exterior walls shall be mounted on thermally insulated sub-base.
5. Relocate space sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
6. Mount space sensors in corridors, stairways and public toilets 7 ft above floor.
7. Space sensors in corridor, stairways, vestibules and toilets shall be aspirating type.

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

E. Direct Insertion Temperature Sensors:
1. Install sensor so that sensor is pointed down stream.

F. Temperature Switches (Aquastats):
1. Install aquastats across discharge face of coil or as close to outlet of coil on return water piping as possible.

G. Aquastats:
1. Aquastats for unit heaters and cabinet unit heats shall be mounted with sensing element in contact with leaving side of coil or the bottom of coil. If sensing element cannot be mounted in contact with coil, mount sensing element on pipe as close to discharge of coil as possible.

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

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

J. 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 pressure transducers integral to DDC panels or separate components to convert digital analog signals to variable pneumatic air pressure signals.
3. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

K. Air Quality Monitors:

1. Provide duct mounting hardware for mounting in return air duct and outside air duct. Where mounting in walk-in plenum, use wall mounted installation.
2. Locate in duct with 3 diameters straight run of duct before monitor for good air flow pattern. Locate wall mounted units in area with good air flow representation.
3. Provide 120 VAC to 24 VAC transformer where monitor requires 24 VAC power.

END OF SECTION

SECTION 23 0923 DIRECT DIGITAL CONTROLLERS AND NETWORKS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control Systems Integration

B. Section 23 0903 - Control Instrumentation

C. Section 23 0993 - Control Sequences

D. Control Sequences: Refer to Drawings

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 DEFINITIONS

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

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

14. Minimum Send Time: An adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.
15. Maximum Send Time: An adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.
16. BTL: BACnet Testing Laboratory.
17. Channel: One or more segments not containing a router.
18. Domain: A logical collection of devices on one or more channels.
19. FLN: Floor Level Network. BACnet MS/TP.
20. HMI: Human-Machine Interface. Graphical operator BAS interface. Same as Graphical User Interface (GUI).
21. LAN: Local Area Network. Same as Floor Level Network.
22. Maximum Send Time: Event driven communication parameter specifying the time period for which data must not be sent more than once.
23. Minimum Send Time: Event driven communication parameter specifying the time period for which data must be sent at least once.
24. PICS: Protocol Implementation Conformance Statement. Detailed description for a given BACnet device stating its inherent BACnet capabilities.
25. Point: Group of data, which corresponds to a hardware input, output, or calculated value.
26. PPC: Programmable Process Controller. Same as Advanced Application Controller (AAC)
27. Scheduling: The exchange of data between devices related to the establishment and maintenance of dates and times at which specified output actions are to be taken.
28. Send on Delta: Event driven communication parameter specifying the amount of variable change before data is to be sent between the Minimum and Maximum send times.
29. SLC: Supervisory Level Controller. Same as Building Controller.
30. Segment: A section of uninterrupted cable where multiple devices may be installed.
31. Subnet: Logical division of a domain.
32. Trending: The accumulation of (time, value) pairs at specified rates for a specified period duration.

1.4 SUBMITTALS

A. Shop Drawings:

1. Submit shop drawings for each hardware device used and submit complete description of software applications used. Submit manufacturer's printed product data sheets for each device or software program used. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.

2. Submittals shall include points list of each control input and output, controlled devices, locations of devices, and symbol or label of each control point in software.

B. Operating and Maintenance Manuals: Refer to Section 23 0901 - Control Systems Integration.

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

1.5 WARRANTY

A. Provide 1 year warranty on all materials and labor.

B. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.6 FCC COMPLIANCE

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

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) CONTROLLERS

A. General:

1. DDC controllers shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each controller shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform intended function.
2. DDC controller shall receive discrete electrical and/or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control devices. Inputs and outputs, including communication connections, shall be electrically or optically isolated from controllers.
3. All BACnet devices shall be BTL certified or BTL compliant.
4. All DDC controllers shall be provided by the same manufacturer.
5. DDC controller with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
6. DDC controller with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
7. Provide input modules capable of interfacing with pulsed output type sensors as required.
8. DDC controller with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate output point status.
9. DDC controller shall have capability to scale, offset, and display proper analog value without field hardware modification. DDC controller shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes. Some application specific controllers may utilize tri-state or Triac outputs for floating point control of control devices. Floating point control should be limited to non-critical room temperature control and mechanical space heating and cooling.
10. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If DDC controller uses database values from other DDC controllers and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.
11. Failure of network or control devices (i.e. building level controllers, floor level controllers, application specific controllers, routers, etc.) shall be alarmed at the Operator Workstation as a Level 3 Critical Alarm.
12. All DDC Hardware shall meet the following requirements:
    a. All DDC controllers shall be connected to an ASHRAE 135 MS/TP, BACnet/IP control network and communicate via ASHRAE 135 exclusively.
    b. MS/TP controllers shall operate at a minimum baud rate of 38.4 kbps.
    c. All DDCP shall implement all required functionality of the application network interface via BACnet objects, properties, and services.
    d. All DDC controllers shall conform to the BACnet Testing Lab's Device Implementation Guidelines and be BTL Listed.
    e. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings.

f. All settings and parameters used by the application shall be fully configurable to the greatest extent possible, via properties of BACnet objects that can be written to via BACnet services or via properties of BACnet objects that can be written to via BACnet services for the following:
   1). Setpoint
   2). Alarm limit
   3). Schedule modification
   4). Trend modification

g. All other settings and parameters that cannot be written to via BACnet services shall be fully configurable via either properties of BACnet objects that can be written to with a configuration tool, or via hardware settings on the controller itself to support the application.

13. Each DDC panel shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in point schedules. If DDC controller does not have sufficient capacity, provide additional slave I/O panels to achieve required point count.
14. Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC panel. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.
15. For function short names and building short names and numbers, contact the University Controls Engineering Department.
16. Contractor shall provide all equipment, engineering and technical specialist time to check the installation required for a complete and functioning system. The contractor shall furnish and install all interconnecting system components. Components to include, but not be limited to: power line conditioners, field panels, sensors, motor starter interfaces, and any other hardware items not mentioned above but required to provide the Owner with a complete workable system.
17. Any feature or item necessary for complete operation, trouble shooting, and maintenance of the system in accordance with the requirements of this specification shall be incorporated, even though that feature or item may not be specifically described herein. This shall include hardware and software.
18. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall be thoroughly tested and proven in actual use.
19. Contractor shall provide all equipment, engineering and technical specialist time to check the installation required for a complete and functioning system. The contractor shall furnish and install all interconnecting system components. Components to include, but not be limited to: power line conditioners, field panels, sensors, motor starter interfaces, and any other hardware items not mentioned above but required to provide the Owner with a complete workable system.
20. Any feature or item necessary for complete operation, trouble shooting, and maintenance of the system in accordance with the requirements of this specification shall be incorporated, even though that feature or item may not be specifically described herein. This shall include hardware and software.
21. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall be thoroughly tested and proven in actual use.
22. The system as specified shall monitor, control and calculate all of the points and functions as listed in the Input/Output Summary.

B. BACnet Building Controller (B-BC):
   1. BACnet Building Controllers (B-BCs) shall provide direct connection to high speed, BACnet/IP Local Area Network (LAN) and Campus Ethernet network and serve as communications router for other controllers on slower speed BACnet MS/TP Floor Level Network (FLN).
   2. B-BC controllers shall be:

a. Tridium N4 JACE 8XXX with 4.6 or greater using most current version of JAVA or HTML 5

b. Building Controller (B-BC) shall be minimum 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

c. The B-BC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board B-BC controller database shall be performed on-line using the built-in software. Systems which require the B-BC to be removed from service while DDC control sequences are modified shall not be acceptable.

d. The B-BC controller shall additionally provide diagnostic LED indication of device transmit and receive data communications for all communication port and peripheral ports, normal operation, abnormal operation and control relay operation indication.

e. The B-BC controller shall provide commanded override capability from the built-in operator interface. Such overrides shall be annunciated to the head-end station. Such overrides shall be valid as long as power is applied to the controller.

f. B-BC controllers shall utilize true floating point arithmetic capabilities.

g. All B-BC controllers shall have open licensing to connect to existing UK UEM Tridium BACnet BAS.

h. B-BC controllers shall be equipped with a minimum of one operator service port for the connection of a laptop computer. The service port shall be either a built-in standard RS-232 data terminal port, USB port, CAT5 cable or RJ11/12 connection.

i. Connection of a service device, to a service port, shall not cause the B-BC controller to lose communications with its peers or other networked device controllers.

3. All programming defining the functions to be performed by the B-BC, including but not limited to application programs and point database within each B-BC, shall be protected from loss due to power failure for a minimum of 72 hours. All database and backup shall be provided to the UK UEM Controls group.

4. Communication between B-BC's shall be through BACnet/IP communication.

   a. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork. It must support interoperability on the campus area network and function as a BACnet Broadcast Management Device (BBMD) and/or a BACnet router.

5. B-BC's shall have sufficient processor capabilities, hard-drive storage and RAM to implement all types of custom software applications and shall provide supervisory control, scheduling, trend logging & alarm handling functions as follows:

   a. Scheduling:

      1). Each B-BC shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.

   b. Trending:

      1). Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

      2). B-BC shall periodically upload trended data to networked BAS Web Application Server for long term archiving.

      3). Archived data shall be stored in standard database format and shall be made available for use in third-party spreadsheet or database programs.

   c. Alarm Generation:

      1). Alarms may be generated within the system for any object change of value or state either real or calculated. This includes analog object value changes, binary object state changes, and various controller communication failures.

2). B-BC shall periodically upload alarm logs to networked BAS Web Application Server for long term archiving.

6. B-BC's shall have uninterrupted real time clocks capable of time of day, week, and year information to the system as needed to perform software functions. Clock shall be programmed to reset twice per year to allow for Daylight Savings Time. Clocks in multiple DDC Controllers shall be synchronized to automatically match designated B-BC's or Web server. Accuracy shall be within 1 second per day
7. All control sequences programmed into the B-BC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The B-BC shall allow for the creation of unique application control sequences. Batteries shall maintain real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:
   a. Orderly startup of controlled equipment (user defined)
   b. Continuation of control algorithms
   c. Database revision
   d. Logging of power interruption and restoration times
   e. Battery recharging
8. Provide local visual indication and system annunciation of low battery power for each battery.
9. Each B-BC shall include its own micro-processor, power supply, input/output modules, and termination modules as required to perform intended function. Systems that only allow selection of sequences from a library or table are not acceptable.
10. B-BC controllers shall be equipped with a minimum of one operator service port for the connection of a laptop computer. The service port shall be either a built-in standard RS-232 data terminal port, USB port, CAT5 cable or RJ11/12 connection.
11. Connection of a service device, to a service port, shall not cause the B-BC controller to lose communications with its peers or other networked device controllers.
    a. BACnet UDP port number to always be set to 47808 (BAC0).
12. Display and Readout Capability
    a. The B-BC controller shall additionally provide diagnostic LED indication of device transmit and receive data communications for all communication port and peripheral ports, normal operation, abnormal operation and control relay operation indication.
13. Manual/Auto Control and Notification
    a. The B-BC controller shall provide commanded override capability from the built-in operator interface. Such overrides shall be annunciated to the head-end station. Such overrides shall be valid as long as power is applied to the controller.
14. Adjustments
    a. Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all setpoints used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual B-BC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the B-BC. From a single B-BC user interface, any other B-BC shall be accessible and full adjustment capabilities shall be provided.
15. B-BC Naming Convention
    a. No special characters are allowed, except underscores.

b. B-BC devices shall be named using the following naming convention:
   1). B-BC devices shall be named using the following format:
      a). BuildingName_BuildingNumber_Floor_RoomNumber_B-BC Device Type OR
      b). BuidlingNumber_BuildingName_Floor_RoomNumber_B-BC Device Type
c. All B-AAC points shall be named using the following format:
   1). Building_Floor_RoomNumber_Device Type_Equipment ShortName_Function
d. Examples:
   1). A B-BC device located in the Pavilion HA mechanical room HA4001 would be named as follows:
      a). PAVHA_0293_04_HA4001_JACE
   2). An exhaust fan status point for a fan in Pavilion HA mechanical room HA3001 fed directly from the above panel would be named as follows:
      a). PAVHA_03_HA3001_HVA_EF1_STAT
   3). For function short names and building short names and numbers, contact the University Controls Engineering Department.

C. BACnet Advanced Application Controllers (B-AAC):
1. Controls shall be microprocessor based, Advanced Application Controllers (B-AAC's). B-AAC's shall be provided for Air Handling Units, packaged Rooftops, primary and secondary pumping loop systems and other applications as shown on the drawings. B-AAC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the B-AAC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs.
2. All B-AAC controllers shall have open licensing to connect to existing UK UEM Tridium BACnet BAS.
3. Contractor shall provide a minimum of one B-AAC controller per air handling or mechanical system as shown on the drawings.
4. The BAS contractor shall provide and field install all B-AAC's specified under this section. Mechanical equipment manufacturers desiring to provide B-AAC' type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.
5. All input/output signals shall be directly hardwired to the B-AAC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
6. B-AAC's shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The B-AAC's shall communicate with the B-BC at a minimum baud rate of 9,600 baud.
7. B-AACs are defined as having sufficient processor capabilities and RAM to implement all types of custom software applications.
   a. Scheduling:
      1). The B-AAC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

8. B-AACs shall be capable of communicating to BAS network via BACnet MS/TP connected to Building Controller or via BACnet/IP directly.
9. All B-AACs controlling major mechanical equipment/systems and lab equipment monitoring shall communicate via BACnet/IP as indicated on BAS Network Architecture drawings.
10. Provide at least one extra communication port at each B-AAC for direct connecting a notebook computer or hand-held terminal. The port will allow the lab top direct access to any B-AAC or B-ASC in the network.
11. The B-AAC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval. The digital readings shall be on a change of state occurrence for the digital points.
12. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.
13. The B-AAC shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.
14. The B-AAC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the B-AAC, without loss of setting. The battery for the time clock shall be replaceable by the customer.
15. The B-AAC shall be capable of being mounted directly in or on the controls compartment of the air handling system. The B-AAC shall be housed in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The B-AAC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. All logic, control system, power supply and input/output circuitry shall be contained on a single plug –in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The B-AAC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
16. Non-Volatile Memory
    a. All control sequences programmed into the B-BC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The B-BC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table are not acceptable.
    b. All control sequences shall be fully programmable at the B-AAC, allowing for the creation and editing of an application control sequence, while at the unit.
    c. The B-AAC shall be provided with an interface port (standard RS232 data terminal port or USB port) for a laptop computer. The interface port shall allow the laptop to have full functionality as described above. From the interface port or network terminal, the laptop shall be able to directly access any B-AAC or B-ASC in the network.
    d. The B-AAC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.
    e. Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the B-BC. Specifics as to how each B-AAC point will be trended, at the B-BC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the B-BC and the number of B-AAC's per B-BC that can be expected.

f. The B-AAC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.

g. The B-AAC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the B-AAC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The B-AAC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

17. Controller Location

a. To simplify controls and mechanical service troubleshooting, the B-AAC shall be capable of being mounted directly in or on the controls compartment of the air handling system. The B-AAC shall be housed in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The B-AAC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The B-AAC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. Every controller and control panel shall be labeled with a lamacoid plate permanently secured to the device. Sticky tape or glued labels are not acceptable. The labeling shall describe the device and include related information such as MAC address, IP address, BACnet Instance numbers, etc.

c. All power feeds shall be clearly identified and shall include panel number, breaker and electrical panel location if not in the same room.

d. For compatibility to the environment of the air handling unit, B-AAC's shall have wide ambient ratings. B-AAC's shall be rated for service from -40 DegF (Degrees Fahrenheit) to 140 DegF.

e. Contractor shall submit description of location of B-AAC's on all mechanical and air handling equipment.

18. B-AAC Naming Convention

a. B-AAC devices shall be named using the following format:

1). Building_Floor_RoomNumber_B-AAC Device Type_Equipment Short Name

19. All B-AAC points shall be named using the following format:

a. No special characters are allowed, except underscores.

1). Building_Floor_RoomNumber_Device Type_Equipment ShortName_Function

b. Examples:

1). An Air Handler controller in the Pavilion HA mechanical room HA4001 for AHU7 would be named as follows:

a). PAVHA_04_HA4001_HVA_AHU7

2). The mixed air temperature point for the above system would be named as follows:

a). MAT

3). Therefore, when this point is learned, the entire point name will be:

a). PAVHA_04_HA4001_HVA_AHU7_MAT

4). For function short names and building short names and numbers, contact the University Controls Engineering Department.

D. BACnet Application Specific Controllers (B-ASC):

1. Controls shall be microprocessor based Application Specific Controller (B-ASC). B-ASC's shall be provided for Unit Ventilators, Fan Coils, Heat Pumps and other applications as shown on the drawings. B-ASC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the B-ASC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.
2. Contractor shall provide a minimum of one B-ASC controller per unitary system as shown on the drawings.
3. The BAS contractor shall provide and install all B-ASC's specified under this section.
4. All input/output signals shall be directly hardwired to the B-ASC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
5. B-ASC's shall be in continuous, direct communication with the network which forms the facility wide building automation system. The B-ASC's shall communicate with the B-BC at a baud rate of no less than 38,400 baud.
6. B-ASCs are defined as having standard software burned into EPROM, set points in EEPROM or RAM maintained by battery, and are designed to handle specific types of control sequences. B-ASC's shall be provided for Unit Ventilators, Fan Coils, Heat Pumps and other applications as shown on the drawings.
7. Control outputs may be in the form of floating point control or true analog output control of end devices. Floating point control shall be limited to non-critical room temperature control or mechanical space heating and cooling. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input/output signals shall be directly hardwired to the B-ASC.
8. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
9. Provide communication ports integral room temperature sensors/thermostats for interface with local terminal equipment controllers or a low range wireless (Bluetooth®) Commissioning tool that provides a temporary wireless connection between the MS/TP network and the laptop computer used to commission.
10. The B-ASC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval. The digital readings shall be on a change of state occurrence for the digital points.
11. Specifics as to how each B-ASC point will be trended, at the B-BC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the B-BC and the number of B-ASC's per B-BC that can be expected.
12. The B-ASC shall be mounted directly in the controls compartment of the unitary system. The B-ASC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to made while at the unitary equipment. The B-ASC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
13. Contractor shall submit description of location of B-Asc's on all mechanical and unitary equipment.
14. Non-Volatile Memory
    a. All control sequences programmed into the B-ASC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the B-ASC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The B-ASC shall allow for the creation of unique application control sequences.

b. The B-ASC shall be provided with the ability to interface with a laptop computer. The interface port shall be provided at the wall sensor or within the unitary equipment. Connection to the wall sensor must be a standard RJ-45 or USB port.

c. The B-ASC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.

d. Systems unable to provide the above capability shall provide for the individual input/output point trending at the B-BC. Specifics as to how each B-ASC point will be trended, at the B-BC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the B-BC and the number of B-ASC's per B-BC that can be expected.

15. Controller Location

a. To simplify controls and mechanical service troubleshooting, the B-ASC shall be mounted directly in the controls compartment of the unitary system. The B-ASC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The B-ASC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the unitary equipment, B-ASC shall have wide ambient ratings. B-ASC's shall be rated for service from 32 DegF (Degrees Fahrenheit) to 140 DegF.

c. Contractor shall submit description of location of B-ASC's on all mechanical and unitary equipment.

16. B-ASC Naming Convention

a. B-ASC devices shall be named using the following format:

1). No special characters are allowed, except underscores.

2). Building_Floor_RoomNumber_B-ASC Device Type

b. Examples:

1). A VAV controller in the Pavilion HA room HA498 would be named as follows:

a). PAVHA_04_HA498_VAV

2). The discharge air temperature point for the above room would be named as follows:

a). DAT

3). Therefore, when this point is learned, the entire point name will be:

a). PAVHA_04_HA498_VAV_DAT

4). For function short names and building short names and numbers, contact the University Controls Engineering Department.

E. BACnet Router

1. BACnet MS/TP to BACnet/IP and to BACnet/IP Routers shall perform layer 3 routing of BACnet MS/TP packets over an IP network in accordance with ASHRAE 135 Annex J. The router shall provide the appropriate connection to the IP network and connections to the BACnet MS/TP network. BACnet Routers shall be capable of configuration via DHCP and Write-Broadcast-Distribution-Table messages but shall not rely on these services for configuration.

2. One router in the IP subnetwork shall be designated as the BBMD (BACnet Broadcast Management Device) and shall be indicated as so on the Network Architecture.

3. BACnet router functionality can also be incorporated into BACnet Building Controllers.

F. Power Supplies:

1. Power supplies shall operate on nominal 120 V, 60 Hz, single-phase power. DDC Controllers shall be provided with surge and noise protection. Power fluctuation shall not affect control system. Include surge protection on telephone line.
    a. Isolation transformers shall be included when connections are being made between 2 separate buildings.

2.2 DIRECT DIGITAL CONTROL SOFTWARE

A. General:

1. All software required for monitoring, modifying, configuring and backup for the system shall be embedded in the controller and accessible via VT terminal, hyper-terminal or the web. This software shall allow any computer with access (and security) to the University's network to perform the work described above using a web browser or provided software. No software upgrades should be required unless provided at no additional cost to the customer. The software version used for installation of any new devices must either be at the current software version used on the University Facilities Management campus at the current JAVA version or the new software at the most current JAVA version must be installed on all devices and the current system prior to the installation of the new devices. All software is to also operate on the latest version of Microsoft Windows operating system. All configuration and programming tools required for the upgraded version must be provided at the time of installation.
2. Provide a USB, standard RS-232 9 pin female, Bluetooth, RJ11, RJ12 or RJ45 connection for on-site access. DDC Controller control strategies shall be Owner definable from engineering workstations.
3. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and shall be able to maintain continuous control as intended.
4. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDC Controller manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.
5. Allow operators to assign unique identifiers of their choice to each connected point. Identifiers shall have at least 8 alpha/numeric characters. References to these points in programs, reports and command messages shall be by these identifiers.
6. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring, set point adjustment, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.
7. Each DDC Controller shall contain self-diagnostics that continuously monitor proper operation of panel.
8. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.
9. Control software and hardware for equipment operation shall be selected and engineered such that equipment shall function according to sequence of operation described in section 23 0993 – Control Sequences with interruption to network communication for extended periods of time.
10. Configuration software for all controllers shall be embedded in the controllers and shall be accessible through Internet Explorer, telnet, or hyper terminal.

B. Building Controller Software:

1. Provide DDC Controller software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks, etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychometrics, duty cycling and client tailored programs

required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.

2. Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):
   a. User interface and online system configuration software embedded in Building Controller.
   b. Support for Web services at the automation network level.
   c. Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.
   d. Changing or overriding any database value.
   e. Error detection, correction, re-transmission of database values, arithmetic or logical faults.
   f. Alarm reporting including sending alarms to remote workstations, User Interface Web Server or Data Historian on network.
   g. Alarm buffer to retain alarms in order of importance without losing any alarms.
   h. Creating and displaying historical trend logging of any value, limited only by available memory.
   i. Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
   j. Adding new hardware points without overall BAS shutdown.
3. Building Controller shall as a minimum support MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Clock Functional Group
   b. Files Functional Group
   c. Reinitialize Functional Group
   d. Device Communications Functional Group
   e. Event Initiation Functional Group
4. Please refer to end of this section for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data.
5. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. Alarms should also be setup on this system with limits. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data.
6. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork. It must support interoperability on the campus area network and function as a BACnet Broadcast Management Device (BBMD) and/or a BACnet router.

C. B-ASC Controller Software:
   1. Manufacturer's standard software for B-ASC's may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDC Controller (B-AAC) capable of being programmed for specified control sequence.

2. Provide software for portable PC units to communicate with terminal controllers at the room level network. Software shall allow access to modify, delete or create control strategies at the room sensor location.

2.3 WEB APPLICATION SERVER

A. Refer to 25 0924 – Graphical user Interface Integration.

2.4 DDC ENGINEERING (PROGRAMMING) - SOFTWARE

A. Provide engineering software for **5** Engineering Servers/Workstations.

B. Software shall have the same characteristic and capabilities as DDC Controllers. In addition, operator's workstations shall have the following features.

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

2.5 NETWORK HARDWARE

A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.

B. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in Section 23 0901 - Control Systems Integration.

C. Provide other network support devices that are required for proper operation of network, such as file servers, network hubs, etc.
   1. Signal repeaters are not allowed for University of Kentucky building automation networks. Unless approved by the University.

D. Provide network diagnostic tool for measuring/confirming bandwidth usage on IP layer.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment in neat, professional manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of DDC Controllers and network cabling and devices.

C. Install DDC Controllers and network control devices in accessible locations.

3.2 OVERALL BAS ARCHITECTURE

A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water flow rate control, and air handling unit temperature control, or 10 seconds or less for other control loops.

B. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller and shall not be distributed amongst multiple controllers. If multiple pieces of equipment are to be interlocked, a single “Master” controller shall provide control for all interlocked pieces of equipment, i.e. an AHU and interlocked return fan and exhaust fans.

C. Control loop software algorithm for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.

D. Networks that operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications, shall have redundant components to maintain network in event of failure at central device. Provide automatic changeover (without operator intervention) to redundant device upon failure of any central type processor.

E. Floor Level Network (FLN) network shall be multi-drop digital transmission network utilizing BACnet MS/TP (38.4kbs) communication.

F. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. Multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.

G. Communications between Building Level DDC Controllers and operator's workstations shall be peer-to-peer, allowing multiple users to access and use system simultaneously with no loss of system performance.

H. Provide levels of connected networks to connect all DDC Controllers, including terminal DDC Controller. Communications to terminal devices shall be similar to capabilities and functions of other DDC Controllers and shall be transparent to operator.

I. Quantity of nodes (devices connected) on any one FLN (MS/TP) shall not exceed 50% of maximum node capacity published by equipment manufacture and Building Controller processor usage shall not be greater than 30% nominal. Provide additional hardware to meet this requirement.

J. Alarm reports from DDC Controllers shall not be impeded by use of either remote or local monitor, or control stations on network either in access mode or programming mode.

K. Provide transient voltage surge suppression devices for controllers and other electronic devices requiring separate line voltage power source.

3.3 DIRECT DIGITAL CONTROLLERS

A. DDC Controller Usage:

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

B. Point Capacity:

1. Provide point capacity required plus spare I/O point capacity in each B-AAC. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices.
2. Spare points in each B-AAC shall be a minimum expansion capability of 20%.

C. Building Controllers:

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

D. Cabinets:

1. Provide local control cabinets for DDC Controllers. DDC Controller cabinets may be used directly if enclosures are rated for NEMA 1. All cabinets shall utilize a single master key. Provide 2 spare key sets to Owner. Otherwise shall be 0.06-inch-thick, furniture-quality steal or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.
2. All control cabinets shall be labeled. Labels shall be keyed to the unique identifiers shown on the As-Built drawings.
3. Panel boards shall be wall-mounted or stand-mounted and shall be completely enclosed with engraved nameplate.

4. Panelboard shall contain all instruments and accessories. Provide each item of equipment with an engraved nameplate. Panelboard shall be wall mounted or stand mounted and shall be completely enclosed.
5. As far as is practical, the control components for each system shall be grouped. Provide each group of components with identification.
6. The entire panelboard shall be pre wired and brought to a main terminal strip. All relays, switches, etc., shall be installed, furnished and wired on panelboard. Clearly mark each terminal strip as to which wire from which component is to be connected.
7. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.
8. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
9. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
10. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.
11. All panel board shall be pre-wired and brought to a main terminal strip. All relays, switches, etc., shall be installed, furnished and wired on panel board. Clearly mark each terminal strip as to which wire from which components is to be connected.
    a. Panel-Mounted equipment includes temperature controllers, humidity controllers, relays, and automatic switches (except for safety devices). Mount devices with adjustments accessible through front of panel.
    b. Door-Mounted equipment shall be flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
    c. Color-coded graphic, laminated-plastic displays, schematically showing system being controlled, with protective clear plastic sheet bonded to entire door.

E. Controller Firmware

1. Provide latest version of controller firmware. Include firmware updates for period of one year after system acceptance, coinciding with warranty period. If the upgrade of firmware causes the need to upgrade or reconfigure/reprogram related systems, controllers or software, Contractor shall notify Owner prior to upgrade and provide additional work scope in coordination with other Contractors, as required, at no cost to Owner.

3.4 DDC SOFTWARE INSTALLATION

A. Operating system (OS): Contractor shall install the OS on workstations and laptops and configure user names and passwords.

B. Virus Protection software: Contractor shall install the virus protection software on each server, laptop and workstation and shall configure weekly virus scans.

C. Contractor shall install and configure all software packages required to maintain and configure all types of controllers provided as part of this project on each engineering workstation.

D. Software from panels shall be permanently stored on CD ROM and on at least one hard disk at operator's workstation or Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

E. Provide the latest version of all standard software, including operating system and control software. Include any software updates for period of one year, coinciding with warranty period. Beta released software shall not be used.

3.5 INITIAL PROGRAMMING

A. Control Contractor shall provide initial programming of controllers to accomplish sequences specified.

B. Provide back-up documentation per software manual submittals for all programs, in both written and electronic media formats.

C. Outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return air, relief air, smoke dampers, heating valves, cooling valves, humidifier valves, etc., shall each have separate output.

D. BACnet Naming and Addressing

1. Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP, assign from range as indicated by vendor documentation.
2. Instance number will be assigned by owner. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.
3. Every BACnet Building Controller (B-BC) and BACnet Router UDP port number shall be set to 47808 (BAC0).
4. Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.
5. The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".

E. Minimum BACnet Object Requirements

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

7. Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint and all constraints associated with Object, such as Proportional Constant, Integral Constant, and Derivative Constant for Loop Object, using BACnet read/write services.

F. Minimum BACnet Service Requirements

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

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	(User Defined)

G. Data Sharing:

1. Data communication from Building Controllers to Engineering Workstation and BAS web server shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit net work traffic.
2. Data communication parameters for analog values shall be operator configurable and setup as follows:
   a. Minimum Send Time: 2 seconds
   b. Maximum Send Time: 60 seconds
   c. Send on Delta (COV) :
      1). Space Temperature: ±0.5°F
      2). Process Temperature: ±0.5°F
      3). Air Pressure, AHU: ±0.05“ W.C.
      4). Relative Humidity: ±0.5%
      5). Air Flow: ±200 cfm
      6). Water Flow: ±50 gpm
      7). Water Pressure ±0.2 psi
      8). Space Pressure: ±0.01“ W.C.

3. Digital data points shall be sent whenever a state change occurs.

H. Historical Trending:
   1. All trending alarms, archiving, scheduling, alarm management, graphics are to be done by UEM..

I. UEM, when adding to an existing system, groupings, tag names, descriptions, engineering units, etc. shall match the existing system. Transitions from the existing system to the new system shall be seamless in look, functionality, and operation.

J. Program historical file for run-times and quantity of start/stops of motor driven equipment.

K. Program maintenance alarms based on run-times and quantity of start/stops for motor driven equipment.
   1. Provide the following additional alarms:
      a. Controller loss of communications for each controller.
      b. Controller battery alarm for each controller (where available)
      c. Out-of-range, bad, or missing data (fault) for each device.

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

M. Time Schedules:
   1. Provide time schedules for HVAC components/systems as indicated in Control Sequences.
   2. All time schedules shall be fully configured with weekly schedules and all holidays identified by the Owner.
   3. Time schedules are to reside in the Building Controllers.

3.6 POINT LIST

A. Provide points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional points listed in point schedules or defined in Control Sequences.

B. All points shall be named per the UEM naming convention with a detailed description.

3.7 AUTO-DIAL ALARM MESSAGES

A. Program up to 30 types of prerecorded voice or fax messages assigned to different alarm types. Assign up to 10 phone numbers for each message. BAS shall automatically call phone numbers without answering machines in predetermined order. If an acceptable phone response is not received after 6 rings (adjustable), system shall automatic retry 3 times (adjustable) before calling next number. Systems shall print level 3 alarm message if no phone numbers were reached.

3.8 GRAPHICS PROGRAMMING

A. Graphics shall be done by UEM.

END OF SECTION

SECTION 23 0993 CONTROL SEQUENCES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - 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.

B. Refer to Control/Flow Diagrams and Control Points List for additional information.

C. Alarms

1. All Control and alarm setpoints shall be adjustable from the operator's workstation for the Tridium Enterprise System or at local controllers via laptop software unless otherwise noted.
2. BAS shall annunciate alarm conditions when analog input values exceed their programmed ranges.
   a. Unless otherwise noted, alarm ranges shall be:
      1). Air Temperature: +/-5°F from setpoint
      2). Water Temperature: +/-10°F from setpoint
      3). Humidity: +/-10% RH from setpoint
      4). Air Pressure: +/-0.5" W.C. from setpoint
      5). Water Pressure: +/- 5 psig from setpoint
      6). Flow: +/-25% of maximum flow range
      7). Level or Value: +/-5% of maximum level or value from setpoint
3. All references to alarms, alarm setup, and alarm enunciation are to be programmed in the UK Tridium system and shall not be programmed in the BAS to annunciate at a non-Tridium workstation. Controls contractor shall coordinate all alarming with UK staff for required alarms.
   a. The contractor is set up the alarm parameters specified by the system sequences of operations without enabling the alarms. Contractor is to provide a list of points containing alarm extensions to PPDMC. PPDMC will be responsible for doing the alarm names, alarm texts and enabling the alarm points provided on the list.
4. Program alarm levels as indicated in sequences, based on the following levels.
   a. Urgent
   b. High Priority
   c. General Maintenance
5. All Input/Output points and BAS data objects shall have alarm parameters available for defining alarms.
6. Alarm monitoring and programming functions shall be restricted by password protection.

7. Coordinate alarm action requirements (printing, automatic dialing, etc.) with Owner.
8. Alarms shall remain active until alarm condition has cleared and alarm is reset manually.

D. Setpoints

1. All controlling setpoints shall be field-adjustable. The Control Contractor shall work in conjunction with the owner, commissioning agent, and Testing and Balancing Contractor to field adjust all final set points.
2. Control Contractor shall verify setpoints, time intervals, and limits based on actual field conditions. All setpoints, time intervals, and limits shall be optimized to achieve stable system operation, prevent damage to equipment, minimize maintenance requirements, and eliminate nuisance alarms (such as premature filter loading, false tripping of freezestats, and other similar conditions).
3. The terms 'Adjustable Temperature Sensor' and 'Non-adjustable Temperature Sensor' are used to describe space temperature sensors.
   a. Adjustable/User-Adjustable Temperature Sensor – space temperature sensor is provided with a slide or buttons that allow the space occupant to locally adjust the setpoint. All Adjustable Sensors shall be programmed with a locked/limited range. The range shall be displayed on the BAS graphic for each space and shall be adjustable from the graphic.
   b. Non-Adjustable Temperature Sensor – Flat plate type or plastic with no local adjustment. Setpoints are programmed at the BAS and shall be adjustable from the graphic for each room.

E. Switch Point Actuation

1. Provide each switch/alarm trip point with an adjustable time delay to prevent nuisance tripping. These time delays apply to all switch points whether hardware or software and for normal operation. Additional or longer delays may be necessary during start-up or shut down as noted herein.
2. Unless otherwise specified, the time delay shall be as follows:

Process or operation	Time Delay
Flow	2 minutes
Motor starter	1 minute
Liquid pressure	1 minute
Gas pressure	1 minute
Pressure differential	1 minute
Level	30 seconds
Valve limit switch	2 minutes
Temperature indoor	5 minutes
High/Low Pressure Switch	5 second
High/Low Temperature Switch	5 second

3. If the time delays are less than the controller scan rate, the minimum controller scan rate shall be the time delay.

F. Variable Frequency Drives

1. VFDs shall be switched between HAND, OFF, and AUTO modes via manual local control adjustment at each VFD.
2. Control loops other than volume/pressure control loops using VFD speed outputs, shall continue to function in the HAND mode.
3. Motors shall operate at constant speed in the HAND mode. Remote start/stop control shall be via local control at each VFD.
4. All safety devices shall be wired as to be still active in the HAND mode.
5. Coordinate communication requirements with VFD manufacturer. All monitoring and control point data from VFD interface card shall be mapped to the BAS. VFD start/stop control and speed control points shall be hard wired from the BAS controller to the drive.

6. The control contractor shall coordinate with the Testing and Balancing Contractor to establish all final minimum and maximum VFD speeds. All minimum and maximum speeds listed in this specification are initial setpoints only.

G. Pressure Transmitter/Sensors

1. Pressure transmitter/sensors shall be hardwired directly back to the BAS controller that provides the control signal to the VFD(s). Sharing the static pressure or pressure differential signal via the network is not allowed for control. Each AHU shall have at least 1 pressure transmitter hardwired directly back to each AHU controller.
2. All locations of pressure transmitters/sensors shall be supplied to the owner for inclusion on the building graphics.

H. Safety Devices

1. All safety devices (low limits, high limits, etc.) shall have local manual reset.
2. All safety devices shall be wired as to be still active when a VFD is in the HAND mode.

I. Pump or Fan Operation Feedback

1. When a device is required to run, the control system shall command the device to start by energizing the discrete output to the motor starting device. The device shall run until the control system commands the device to stop by de-energizing the discrete output to the motor starting device or an equipment failure occurs.
2. Equipment failure is detected by opening of a low current switch, pressure differential switch, current input in Low-Low alarm condition (VFD), or VFD fault input when the device is commanded on, or is operating, or anytime the device status does not match the commanded state. If a failure occurs, the device shall be stopped and an alarm shall be generated at the BAS, designating that device has failed (see each sequence for alarm type details). This interlock shall be disabled for 30 seconds (FA) after the device is initially commanded to start. Failed pump or fan shall be locked out until manually reset through the BAS.
3. Current switches affixed to one of the motor feed cables or pressure differential switch piped across inlet and outlet of fan or pump shall be used for equipment status indication.

3.2 POWER FAILURE MODE SEQUENCE

A. General:

1. Power failure shall be determined by position of automatic transfer switch in conjunction with test mode indication from power management system. Control Contractor is responsible for obtaining status signal and all necessary wiring for status signal from automatic transfer switches to BAS.
2. Pump and fan VFDs shall be programmed for automatic restart after a complete stop upon power resumption when normal power is lost and automatic transfer switches are in the essential power system position.
    a. Test mode indication from power management system shall be monitored by the BAS. During the monthly routine tests of the power system when test mode status is indicated, pumps and fans served by essential power shall not be shut down and restarted when automatic transfer switches are in essential power position.
3. All control valves serving reheat coils shall maintain their last control position upon loss of power or loss of control signal.

B. Managed Restart:

1. BAS shall monitor normal power indication and on loss of normal power for duration of 2 seconds (FA) or longer, all equipment shall be commanded stopped by the BAS. When Essential Power is established as indicated by automatic transfer switches, BAS shall restart system components served by Essential

Power based on the following Priority Sequence. Start sequence under each automatic transfer switch shall not begin until associated automatic transfer switch has been proven switched to the generators. Equipment designated to operate on essential power, but not included in the following priority list (referred to hereinafter as "subsequent" equipment) shall not start until priority equipment start-up sequence is complete. Start-up of subsequent equipment shall not be delayed for proof of actual operation of priority equipment. Once all priority equipment has been commanded to start, proceed immediately to start-up of subsequent equipment. Provide software adjustable time delay between starting of components serving a common system (set initial delay at 5 seconds (FA)).

2. Equipment operating under essential power shall not exceed the respective system capacity requirements. Capacity control sequencing (lead-lag control for capacity control) shall remain in effect during essential power operation. The following priority sequence indicates the equipment designated (given permission) to operate on essential power if needed by system capacity control sequence and the relative operation priority of that equipment.

C. Priority Sequence:

1. Automatic Transfer Switches shall be monitored by the BAS via MODBUS connection. Monitor the following status:
   a. Switch in Normal Position
   b. Normal Source Not Available
   c. Switch in Essential Position
2. Upon power failure, HVAC equipment shall begin restarting in sequence as indicated below upon indication the equipment's respective Automatic Transfer Switch (ATS) has switched to Essential Power. No delay shall be programmed on a switch back to Normal Power from Essential power. Refer to electrical schedules, control sequences, and DDC points schedule for equipment connected to Essential Power and ATS the equipment resides on.
3. When Equipment ATS is proven in the Essential Power position by contacts, the following HVAC devices shall be started in order listed by respective ATS as indicated in device sequences following with 5 second (FA) intervals between restart of devices:
   a. AHUs
   b. Exhaust Fans
   c. Terminal Units

3.3 AIR HANDLING UNIT BT-51AW & BT-51AE

A. General:

1. Refer to drawing IC710 & IC711.
2. Units are variable volume.
3. Each air handling unit consists of:
   a. Supply fan array with backdraft damper on each fan
   b. Return fan array with backdraft damper on each fan
   c. Heating coil
   d. Cooling coil
   e. Heating coil pump
   f. Cooling coil pump
   g. Humidifier
   h. Pre-filter and final filter
   i. Carbon filter
   j. Ion filter

k. Exhaust/relief air damper
l. Mixing air damper
m. Outside air damper
n. Return air smoke/isolation damper
o. Supply/discharge air smoke/isolation damper

4. AHU is designed for outside air with an economizer control.
5. Supply and Return fan motor status is indicated by a current switch on each fan.

B. Interlocking:

1. Return fans shall be software interlocked with supply fans respectively so that return fans operate whenever their associated supply fans operate. Return fans shall start before associated supply fans are allowed to start.
2. Software interlock associated humidifier so that humidifier will be inoperative and humidifier control valve will be fully closed when the following conditions occur.
   a. Unit is off.
   b. Air handling unit is operating in cooling mode and cooling coil control valve is open.
3. When an air handling unit is not operating except during low temperature switch shutdown, control devices shall be in the following positions:

a.	Min Outside air damper	Closed
b.	Max Outside air damper	Closed
c.	AHU discharge smoke/isolation air damper	Closed
d.	Heating coil control valve	Under Control
e.	Cooling coil control valve	Closed
f.	Supply fans	Off
g.	Return fans	Off
h.	Return smoke/isolation damper	Closed
i.	Mixing damper	Open
j.	Exhaust/relief damper	Closed
k.	Heating coil circulating pump	Under control as described in Heating Coil Circulating Pumps – Control Sequence above
l.	Cooling coil circulating pump	Under control as described in Cooling Coil Circulating Pumps – Control Sequence above

C. Unit Operation:

1. Unit operation shall be automatic and activated through BAS.
2. System shall operate continuously.
3. System shall manually start/stop and run continuously by command from operator via BAS command point.
4. When an AHU is commanded to start via BAS command point, the following sequence shall occur:
   a. AHU return fans shall start and hold at minimum speed while relief and return smoke/isolation damper opens. When return smoke/isolation damper is proven open via open position end switch return fans shall be released to control setpoint allowing fans to ramp up.
      1). Whenever the return smoke/isolation damper does not prove open via open position end switch within 60 seconds (FA) of open command, the AHU shall fail, and an alarm shall be

annunciated at the BAS. The failed AHU shall be locked out and remain locked out until manually reset though the BAS.

b. When the AHU return fans are proven operational by current switch, respective AHU supply fans shall start and hold at minimum speed while AHU discharge smoke/isolation damper and outside air damper open. When discharge smoke/isolation damper and outside air dampers are proven open via open position end switches, AHU supply fans shall be released to control allowing fans to ramp up.

5. When system is commanded to stop;
   a. Supply and return fans shall stop, the outside air damper, and relief air damper shall close, and mixing damper shall open. AHU supply and return smoke/isolation dampers shall close when supply and return fans reach minimum speed.
6. When any fan array is commanded to start via bypass contact switch or H-O-A switch on VFD, the following sequence shall occur:
   a. In bypass mode, fan array shall start and operate at full speed, or in hand mode, fan array shall start and operate at speed selected on VFD, and an alarm shall be annunciated at a Tridium workstation.
   b. On indication of bypass switch in bypass mode or H-O-A switch in hand mode, respective smoke/isolation damper shall open. On indication of supply fan array in bypass mode or H-O-A switch in hand mode, minimum outside air damper shall open if closed.
   c. When fan array is proven operational via current switch, the remaining fan array in the unit shall start as indicated in sequence above.

D. Fan Failure Detection:
1. If an AHU supply/return fan failure occurs, as sensed by current switch, an alarm shall be annunciated at the BAS. This alarm interlock shall be disabled for 120 seconds (FA) after the fans are initially commanded to start. Upon failure, affected supply/return fan shall shut down while remaining supply/return fans continue to operate to maintain static pressure setpoint
2. If supply or return fan array VFD failure occurs, as detected VFD fault indication from VFD output, the fans shall be stopped and an alarm shall be annunciated at a Tridium workstation. This alarm interlock shall be disabled for 60 seconds (FA) after the fans are initially commanded to start. Upon failure, the AHU shall be shut down.
3. Provide manual reset switch at the AHU temperature control panel to reset unit locally as well as through the BAS.
4. Each alarm shall automatically return to normal when status and command conditions match. The return to normal status shall be recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.

E. System Supply/Return Air Volume Control:
1. Static pressure control shall low select the lowest reading static pressure transmitter of all static pressure transmitters located in remote supply/return ducts. General location for the static pressure sensors shall be indicated on the mechanical duct drawings, for controlling supply/return air static pressure setpoint. Initial setpoint shall be 1.5” WC (FA).
2. On drop in supply/return static pressure below setpoint, as measured by low selected supply/return system static pressure transmitter, the VFD speed shall increase until supply/return static pressure setpoint has been satisfied. On rise in supply/return static pressure above setpoint, the VFD speed decrease until system supply/return static pressure setpoint is satisfied.
3. If low selected static pressure transmitter is 80% less than the other system transmitter, low selected static pressure transmitter shall be alarmed at the BAS, disregarded for the supply/return air static pressure control and remaining static pressure transmitter shall be used for fan control.
4. Control Contractor shall work in association with Test and Balance Contractor to determine actual required static pressure setpoint ranges of each transmitter. Setpoints indicated above are to be used for

initial system startup. Actual static pressure setpoints shall be the minimum static pressure required to achieve system design flow at minimum and maximum design conditions.

F. Damper Control:
   1. The AHU includes a minimum outside air damper, maximum outside air damper, modulating relief air damper, and a modulating mixing damper.
   2. The AHU has two operating modes: Mixed Air Temperature Control and Minimum Outside Air Control.
   3. Minimum Outside Air Mode
      a. Minimum Outside Air Damper Control
         1). When the unit is in Minimum Outside Air Mode, the minimum outside air damper shall be open to provide minimum design outside airflow as scheduled in mechanical drawings.
         2). Control Contractor shall work in conjunction with Test and Balance Contractor to determine required position of minimum outside air damper to provide design minimum outside air airflow.
      b. Modulating Outside Air Damper Control
         1). When the unit is in Minimum Outside Air Mode, the modulating outside air damper shall be locked closed.
      c. Relief Air Damper Control
         1). When the unit is in Minimum Outside Air Mode, the relief air damper shall modulate to maintain a slight positive pressure in the relief air duct in relation to the mechanical room, as measured by a static pressure transmitter located upstream of the relief air damper.
         2). On drop in relief air duct static pressure below setpoint, as measured by the relief air duct static pressure transmitter, the relief air damper shall modulate closed until relief air duct static pressure setpoint has been satisfied. On rise in relief air duct static pressure above relief air duct static pressure setpoint, relief air damper shall modulate open until relief air duct static pressure setpoint is satisfied.
         3). Control Contractor shall work in conjunction with Test and Balance Contractor to determine required static pressure setpoint in the relief air duct. Initial setpoint shall be 0.1" WG (FA).
      d. Mixing Air Damper Control
         1). When the unit is in Minimum Outside Air Mode, the mixing air damper shall modulate to maintain the minimum outside air flow as measured at the outside air flow measuring station. Refer to air handling unit schedules for minimum outside air flow setpoints.
   4. Mixed Air Temperature Mode
      a. Minimum Outside Air Damper Control
         1). When the unit is in Mixed Air Temperature Mode, the minimum outside air damper shall be open.
      b. Modulating Outside Air Damper and Mixing Air Damper Control
         1). When the unit is in Mixed Air Temperature Mode, the maximum outside air damper and mixing air damper shall modulate in reverse parallel to maintain unit discharge temperate at setpoint.
         2). On drop in mixed air temperature below setpoint, as measured by the mixed air temperature sensor, the maximum outside air damper shall modulate closed while the mixing air damper modulates open until the mixed air temperature setpoint has been satisfied. On rise in mixed air temperature above setpoint, the maximum outside air damper shall modulate open while the mixing air damper modulates closed until the mixed air temperature setpoint has been satisfied.
      c. Relief Air Dampers Control
         1). Relief air damper shall modulate to maintain relief air static pressure as described above.

5. Minimum Outside Air/Mixed Air Temperature Mode Switchover
    1). Provide dry bulb economizer control. Whenever outside air dry bulb temperature exceeds the return air temperature minus 5°F (FA), economizer control shall modulate outside air damper to its minimum position.
    2). Economizer control shall be released when outside air dry bulb temperature is less than return air temperature minus 5°F (FA) for 10 consecutive minutes (FA).
    3). Upon loss of outside air temperature sensor, economizer mode shall be turned off and OA damper shall modulate to minimum position.

G. Unit Discharge Air Temperature Control:
    a. Discharge air temperature shall be controlled through the BAS with temperature sensors located as specified herein.
    b. Heating Coil Discharge Air Temperature Control – Normal Operation:
        1). On a call for heating to maintain the coil discharge air temperature, the AHU must be in Minimum Outside Air mode before the heating coil control valve shall be allowed to modulate open.
        2). Heating coil control valve shall modulate to maintain coil discharge air temperature at setpoint via averaging type sensor upstream of the humidifier.
            a). As coil discharge air temperature decreases, heating coil control valve shall modulate open to maintain coil discharge air temperature at setpoint. The reverse shall occur as coil discharge air temperature increases.
        3). Heating coil discharge air temperature setpoint shall be reset to maintain AHU discharge air temperature at 55°F (FA), as measured by probe type sensor downstream of the discharge air smoke/isolation damper.
        4). Heating coil circulating pump shall start and stop as indicated in HEATING COIL CIRCULATING PUMPS - CONTROL SEQUENCE section.
    c. Heating Coil Discharge Air Temperature Control – AHU Not Running Operation:
        1). Heating coil control valve shall modulate to maintain 48°F (FA) heating coil discharge air temperature anytime AHU is not running and safety low temperature limit control (freeze-stat) is not in alarm.
    2. Cooling Coil Discharge Air Temperature Control:
        a. On a call for cooling, the heating valves shall be closed before the cooling coil control valve shall be allowed to modulate open.
        b. Cooling coil control valve shall modulate to maintain unit discharge air temperature of 55°F (FA) via probe type sensor located in the supply duct downstream of the AHU discharge smoke/isolation dampers.
            1). In cooling mode when outside air temperature is above 49°F (FA) as unit discharge air temperature increases, cooling coil control valve shall modulate open to maintain unit discharge air temperature at setpoint. The reverse shall occur as unit discharge air temperature decreases.
        c. Cooling coil control valve shall be locked in closed position whenever outside air temperature is below 49°F (FA) for 10 consecutive minutes (FA) or whenever associated supply fan is not operating, when safety low temperature limit control (freeze-stat) is not in alarm.
    3. The cooling coil control valve and heating coil control valve shall not be allowed to operate simultaneously.

H. Humidity Control:
    1. Humidifiers - Space Humidity Control
        a. If all supply fans are off, its respective humidifier valves shall close.

b. Humidifier valves shall be enabled when air flow is detected via supply airflow measuring station.

c. Humidifier control package, after being enabled by AHU control, shall be staged open/closed solenoid control valves to maintain exhaust humidity setpoint **30% RH** within ±5% RH of setpoint (FA).

2. Exhaust air humidity sensors are located in return air ducts.

I. Duct Mounted Ion Detector (IDETECT)

1. IDETECT sensor is owner furnished contractor installed. Install sensor in supply ductwork at discharge of AHU.

J. Heating Coil Circulating Pumps

a. Each air handling unit preheating coil has 1 pump, each sized for 100% of the coil design flow.

b. Pre-heating coil circulating pumps shall be energized automatically through Building Automation System (BAS).

2. Pump Operation

a. Primary preheating coil circulating pump shall start whenever its respective preheating coil is enabled to operate, and shall stop when the preheating coil is disabled. Refer to air handling unit sequences for setpoints.

b. Primary preheating coil circulating pump shall start if respective air handling unit freezestat is activated.

c. Minimum pump run time shall be 10 minutes (FA).

d. On failure of preheating coil circulating pump, as sensed by current switch, pump shall be locked out, and an alarm shall be annunciated at the BAS. Pump shall remain locked out until reset manually.

1). Pump failure shall be defined as anytime the pump status does not match the commanded state when commanded state is on.

K. Cooling Coil Circulating Pumps

1. Cooling coil circulating pumps shall be energized automatically through Building Automation System (BAS).

2. Pump Operation

a. Primary cooling coil circulating pump shall start whenever its respective cooling coil is enabled to operate, and shall stop when the cooling coil is disabled. Refer to air handling unit sequences for setpoints.

b. Primary cooling coil circulating pump shall start if respective air handling unit freezestat is activated.

c. Minimum pump run time shall be 10 minutes (FA).

d. Failure of cooling coil circulating pump, as sensed by current switch, pump shall be locked out, and an alarm shall be annunciated at the BAS. Pump shall remain locked out until reset manually.

1). Pump failure shall be defined as anytime the pump status does not match the commanded state when commanded state is on.

L. Smoke Control:

1. Duct Smoke Detectors

a. Duct mounted smoke detectors are specified to be furnished, installed, and wired to the building fire alarm system under Fire Alarm.

b. Each detector shall provide an available contact closure for use by BAS, or an external addressable relay module shall be provided for this function. The contact shall be hardwired by the BAS

contractor to shutdown the supply fan and return fan arrays, and generate a binary input alarm at the BAS. The BAS contactor shall provide a pilot relay if necessary.

c. Through software, this shall disable the supply and return fan arrays, close the minimum and maximum outdoor air dampers, close the exhaust air damper, close the return air damper, close the hot water heating coil valve, stop the humidifier, and close the chilled water valve.

d. The supply/return duct detector shall also be interlocked with the supply isolation damper and return air damper, to close both dampers upon alarm.

M. Safeties:

1. Each of the following safety devices, upon activation, shall generate a unique alarm message at the BAS. Each alarm shall be recorded in the alarm event log. Each alarm shall require an operator acknowledgment at the BAS.
2. Each device shall require a manual reset by the operator at the device. After reset, the operator shall be required to restart the air handling system with a single manual operator command.
3. Each alarm shall automatically return to normal upon manual reset and the return to normal status recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.
4. Provide safety low temperature limit control (freeze-stat), with 3 minute (FA) time delay from fan start signal at entering side of cooling coil. Low limit shall de-energize unit supply fans; close outside air damper, close supply isolation damper, open cooling coil control valve, starting heating and cooling coil pumps; and modulate heating coil control valves to maintain reheat coil discharge air temperature (measured downstream of reheat coil) at 60°F (FA) when air temperature falls below 38°F (FA) over any one-foot section of the freezestat. Low limit shall be functional in VFD H-O-A mode of operation.
5. Provide high static pressure limit control, with sensor located in unit discharge air duct downstream of supply smoke/isolation damper, to limit fan volume control at 4.5” WC (FA) when pressure reaches this value.
6. Provide high static pressure safety switch between discharge of supply fan wall array fans and outlet smoke/isolation damper and wire in series with VFD safety circuits to stop respective supply fans. The pressure switch shall be adjusted to 5.0” WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. High static pressure safety switch shall be functional in VFD hand mode of operation. If high static pressure safety switch is tripped, AHU shall be shutdown.
7. Provide low static suction pressure safety switch downstream of cooling coil and upstream of supply fan wall array fans and wire in series with VFD safety circuit to stop respective supply fans. The pressure switch shall be adjusted to -5.0” WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. Low static pressure safety switch shall be functional in VFD hand mode of operation. If low static suction safety switch is tripped, AHU shall be shutdown.

N. Power Failure Mode:

1. Air handling unit is connected to emergency power:
2. All supply and return fans, and heating coil pumps in the air handling units are connected to emergency power.
3. Upon power failure as indicated by automatic transfer switch, all supply and return fans in the air handling units shall be commanded to stop.
4. When emergency power is established as indicated by automatic transfer switch, supply and return fans, and pump from each AHU shall restart and operate under normal control attempting to meet system air flow requirements. Refer to POWER FAILURE MODE SEQUENCE for restart sequence.
5. Upon resumption of normal power as indicated by automatic transfer switch, operating supply and return fans, and pumps in the air handling units shall continue to operate with no interruption of power.

O. Monitor and Alarm

1. Each alarm shall be recorded in the alarm event log. Each alarm shall require an operator acknowledgment at the BAS.
2. Each alarm shall automatically return to normal when status and command conditions match. The return to normal status shall be recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.
3. Monitor, through BAS, the following points associated with air handling system and generate the alarms indicated:
    a. Discharge air temperature – each AHU (AI)
        1). Generate Urgent Alarm if temperature exceeds setpoint by ±3°F (FA).
    b. Discharge air humidity – each AHU (AI) (See humidit13y control sequence)
        1). Generate Urgent if supply humidity rises above 70% RH (FA).
    c. Heating coil discharge air temperature – each AHU (AI)
        1). Generate High Priority alarm if temperature deviates from setpoint by ±3°F (FA) for 10 consecutive minutes (FA).
    d. Low limit thermostat (freezestat) – each AHU (DI)
        1). Generate Urgent alarm and stop AHU.
    e. Discharge air humidity – each AHU (AI)
        1). Generate Urgent alarm if discharge % RH exceeds setpoint by ±5% RH.
    f. Supply fan VFD status - each fan (DI)
    g. Supply fan VFD Fault – (DI)
        1). Generate Urgent alarm.
    h. VFD H-O-A switch –VFD (DI)
        1). Generate High Priority alarm if switch is in any position other than auto.
    i. Outside air damper position – open and closed (DI)
        1). Generate Urgent alarm if damper is not proven open within 60 seconds (FA) of AHU start signal or closed within 60 seconds (FA) of AHU stop signal.
    j. AHU smoke/isolation damper position – open and closed – (DI)
        1). Generate Urgent alarm if damper is not proven open within 60 seconds (FA) of fan start signal or proven closed within 60 seconds (FA) of fan stop signal.
    k. Prefilter pressure drop – each filter (AI)
        1). Generate General Maintenance alarm when filter pressure drop exceeds setpoint of 0.5” WC (FA).
    l. Final filter pressure drop – each filter (AI)
        1). Generate General Maintenance alarm when filter pressure drop exceeds setpoint of 1.5” WC (FA).
    m. Supply duct static pressure transmitter – each transmitter (AI)
        1). Generate High Priority alarm if pressure deviates from setpoint by ±1” WC (FA) for 5 consecutive minutes (FA).
    n. Fan discharge low static pressure safety switch – (DI)
        1). Stop fan and generate Urgent alarm if pressure exceeds -5” WC (FA).
    o. Fan discharge high static pressure safety switch – (DI)
        1). Stop fan and generate Urgent alarm if pressure exceeds 5” WC (FA).
    p. Duct static pressure transmitter – (AI)
        1). Generate High Priority alarm if pressure exceeds setpoint by ±1.0” WC (FA).

q. Supply fan discharge smoke detector – (DI)

r. IDETECT - Duct Mounted Ion Detector

1). Generate High Priority alarm.

s. Pump current switch – each pump (DI)

1). Generate Urgent alarm anytime pump status does not match commanded state within 60 seconds (FA) of command change of state.

t. Pump H-O-A (Hand-Off-Auto) Switch (DI)

1). Generate Urgent alarm anytime H-O-A switch is in any position other than Automatic.

3.4 GENERAL EXHAUST FAN

A. General:

1. Refer to Detail 1 on drawing IC720.

B. Operation

1. Fan Start/Stop shall be controlled by the BAS. Fan shall operate continuously.

C. Monitor and Alarm:

1. Each alarm shall be recorded in the alarm event log. Each alarm shall require an operator acknowledgment at the BAS. Provide a time delay (set: 5 seconds - adjustable) before generating an alarm.
   a. Exhaust fan current switch – each fan (DI)
      1). Generate Urgent alarm if exhaust fan status does not match commanded state.
   b. H-O-A switch (DI)
      1). Generate Urgent alarm if switch is in any position other than auto.

3.5 TERMINAL UNITS - CONTROL SEQUENCES

A. General:

1. Control Contractor shall furnish DDC controls and actuators to unit manufacturer for factory installation and adjustment. Refer to Section 23 3600 – Air Terminal Devices.
2. Units are system pressure independent type
3. Refer to Air Terminal Device Schedules for determination of control sequence applications.
4. Areas served by multiple supply air terminals with multiple temperature sensors shall have all space temperature sensor readings averaged. The average space temperature shall be used for control of each individual supply air terminal supplying the area.
   a. On failure of one or more temperature sensors as, indicated by loss of control signal, the control loop(s) associated with the failed transmitter(s) shall be removed from the average reading algorithm, an alarm generated at the BAS and the remaining operating temperature sensor(s) shall be used for temperature control.
5. When a space is served by multiple supply air terminals, unless otherwise indicated, controls shall modulate the reheat valves to maintain common supply air temperature from each supply air terminal which is reset to maintain space temperature.
   a. When a space is served by multiple supply air terminals, controls shall modulate the damper actuators in parallel unless otherwise noted in the sequences below.

6. Where humidity sensors are shown, the BAS shall calculate room dew point using space humidity and temperature sensors.
7. The electrical contractor shall provide an occupancy sensor with a dedicated dry contact or relay for each occupancy sensor. Occupancy sensors shall be hard wired from the dry contact/relay to the controller by the Controls Contractor. Where multiple occupancy sensors are shown within a space, wire the sensors in series or parallel to provide one occupied/unoccupied signal to the controller. Occupancy sensors shall be used for control of 'Vacant Mode' as described below in each sequence.
8. Dew point monitoring and safety control (where applicable) shall be active in occupied and unoccupied modes.
    a. When the space dew point rises above 56°F (FA), the chilled water control valve serving the space shall be commanded closed.
    b. When the space dew point drops below 56°F (FA), the chilled water control valve serving the space shall be released back to control per Air Flow Control and Temperature Control.

B. Power Failure Mode:
1. All air terminal devices are connected to essential power.
2. When essential power is established as indicated by automatic transfer switch, all variable volume air terminal devices shall be commanded to their minimum CFM setpoint and locked. Refer to POWER FAILURE MODE SEQUENCE, Paragraph 3.2.
3. Upon resumption of normal power as indicated by automatic transfer switch, normal air terminal control shall resume

C. Monitor and Alarm
1. Refer to Points list for BAS monitoring points for possible points for each sequence and generate the alarms. Additionally, the BAS shall monitor all humidity, CO2, occupancy sensors, room pressure sensors, and points associated with Aircuity.
    a. Space temperature (AI)
        1). Generate High Priority alarm if space temperature exceeds setpoint by ±5°F (FA) for 15 consecutive minutes.
    b. Space temperature fault (DI)
        1). Generate High Priority alarm if space temperature sensor indicates a loss of signal.
    c. Space relative humidity (AI)
        1). Generate High Priority alarm if space temperature exceeds setpoint by ±5%RH (FA) for 15 consecutive minutes.
    d. Supply/Return or Exhaust Offset (AD) – each room
        a). Generate High Priority alarm if offset exceeds setpoint by ±25% (FA) for 15 consecutive minutes (FA).
    e. Occupancy sensor (DI) – each room
    f. Supply air flow (AI) – each room
    g. Supply air flow setpoint (software) – each room
    h. Supply air damper command (AO) – each room
    i. Reheat valve command (AO) – each room
    j. Discharge air temperature (AI) – each room
    k. Fin tube valve command (AO) – each room
    l. Space setpoint temperature (AI) – each room
    m. Exhaust air flow (AI) – each room
    n. Exhaust air flow setpoint (software)

1). Generate level 2 alarm if offset exceeds setpoint by ±5% (FA) for 15 consecutive minutes (FA).

o. For Positive Isolation Patient Room and Negative Ante Room:

1). Provide a pressure sensor/monitor for each room.

2). Provide a local alarm monitoring devices that shall interface with the BAS at the corridor wall and the ante room wall with the following features:

3). Room Pressurization Display.

4). Visual Alarm Indication.

5). Audible Alarm Indication.

6). For patient room monitor, generate Level 1 alarm if respective space differential pressure reduces to +0.01" WC (FA) for 5 consecutive minutes (FA). Space differential set point is +0.015" WC.

7). For ante room monitor, generate Level 1 alarm if respective space differential pressure reduces to -0.01" WC (FA) for 5 consecutive minutes (FA). Space differential set point is -0.015" WC.

D. Air Terminal Unit Control Sequence Number 1 - Constant Volume Supply with Reheat (and fin tube radiation in waiting rooms only):

1. General:
   a. Refer to detail 1 on drawing IC730
   b. Room consists of:
      1). Supply air terminal(s) with reheat coil
      2). Return air terminal(s)
      3). Fin tube radiation (waiting rooms only)
2. Occupied-Unoccupied Mode:
   a. Space shall have single operating mode. Consider space occupied at all times.
3. Air flow control:
   a. Damper actuator (FLP) on constant-volume supply air terminal shall maintain airflow quantity scheduled. DDC CAV controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
   b. DDC panel shall utilize airflow sensors in room return or exhaust air terminal to continuously measure room return or exhaust airflow. CAV controller shall continuously calculate required room exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by adding offset (defined in Air Balance schedules) to room's total supply airflow rate. Damper actuator (FLP) serving exhaust air terminal shall be modulated to maintain predetermined offset.
4. Temperature control:
   a. DDC CAV temperature controller shall measure room temperature by means of electronic space temperature sensor and shall maintain temperature setpoint 72°F (FA) by modulating reheat coil control valve (FLP) and control valve (FLP) on fin tube in sequence. Refer to FIN TUBE/ RADIANT CEILING PANEL – CONTROL SEQUENCE.

E. Air Terminal Unit Control Sequence Number 2 - Variable Volume Supply with Reheat

1. General:
   a. Refer to detail 2 on drawing IC730
   b. Room consists of;
      1). Supply air terminal(s) with reheat coil

2. Occupied-Unoccupied Mode:
    a. Space occupancy sensor shall control space occupancy mode. Occupancy sensor for space lighting shall have dual dry contacts provided for use by Controls Contractor. Occupancy sensor shall be provided and installed by electrical contractor and all associated wiring from occupancy sensor to BAS shall be provided by controls contractor. Refer to air terminal schedule in plans for rooms with occupancy mode control.
    b. Air terminals scheduled with Unoccupied minimum air flows shall include Occupied and Unoccupied controls as indicated below. Air terminals scheduled without Unoccupied minimum air flows shall include occupied controls only as indicated below.
    c. Spaces with multiple occupancy sensors and multiple air terminals shall have occupancy sensors wired in parallel so that any one sensor that is in occupied mode shall command all air terminals serving space into occupied mode.
    d. Occupied Mode:
3. Air flow Control
    a. Air flow control (Occupied Mode):
        1). DDC VAV controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
    b. Air flow control (Unoccupied Mode):
        1). Air flow to the space modulates to maintain unoccupied minimum air flow setpoint as indicated in schedules.
4. Temperature Control
    a. Temperature Control (Occupied Mode):
        1). Electronic space temperature sensor through DDC VAV controller shall modulate damper actuator (FLP) on variable-volume supply air terminal and reheat coil control valve (FLP) in sequence to maintain space temperature setpoint. On a drop in space temperature below the cooling setpoint, supply air terminal shall modulate from maximum to minimum airflow rate as scheduled. On a continued drop in space temperature below the heating setpoint, reheat coil control valve shall modulate open to maintain temperature setpoint. On a rise in space temperature, the reverse shall occur.
    b. Temperature Control (Unoccupied Mode):
        1). When space is unoccupied, temperature control shall operate the same as occupied mode incorporating a ±5°F (FA) offset in the space temperature setpoint.

F. Air Terminal Unit Control Sequence Number 3 - Constant Volume Supply with Reheat, Exhaust/Supply Air Tracking (for Positive & Negative Rooms):
1. General:
    a. Refer to detail 3 on drawing IC730
    b. Room consists of:
        1). Supply air terminal(s) with reheat coil
        2). Return or exhaust air terminal(s)
2. Occupied-Unoccupied Mode:
    a. Space shall have single operating mode. Consider space occupied at all times.
3. Air flow control:
    a. Damper actuator (FLP) on constant-volume return or exhaust air terminal shall maintain airflow quantity scheduled. DDC CAV controller shall utilize airflow sensor in return or exhaust air terminal to continuously measure return or exhaust flow rate.

b. DDC panel shall utilize airflow sensors in room supply air terminal to continuously measure room supply airflow. CAV controller shall continuously calculate required room supply airflow rate necessary to maintain predetermined offset, between total supply and return or exhaust airflows, by subtracting offset (defined in Air Balance schedules) from room's total return or exhaust airflow rate. Damper actuator (FLP) serving supply air terminal shall be modulated to maintain predetermined offset.

c. Temperature control:

d. DDC CAV temperature controller shall measure room temperature by means of electronic space temperature sensor and shall maintain temperature setpoint of 72°F (FA) by modulating reheat coil control valve (FLP).

e. On a drop in space temperature below setpoint, reheat coil control valve shall modulate open. The reverse shall occur as the space temperature rises above setpoint.

G. Air Terminal Unit Control Sequence Number 4 - Variable Volume Supply with Reheat, Supply/Return or Exhaust Air Tracking:

1. General:
   a. Refer to detail 4 on drawing IC730
   b. Room consists of;
      1). Supply air terminal(s) with reheat coil
      2). Return or exhaust air terminal(s)
2. Occupied-Unoccupied Mode:
   a. Space occupancy sensor shall control space occupancy mode. Occupancy sensor for space lighting shall have dual dry contacts provided for use by Controls Contractor. Occupancy sensor shall be provided and installed by electrical contractor and all associated wiring from occupancy sensor to BAS shall be provided by controls contractor. Refer to air terminal schedule in plans for rooms with occupancy mode control.
   b. Air terminals scheduled with Unoccupied minimum air flows shall include Occupied and Unoccupied controls as indicated below. Air terminals scheduled without Unoccupied minimum air flows shall include occupied controls only as indicated below.
   c. Spaces with multiple occupancy sensors and multiple air terminals shall have occupancy sensors wired in parallel so that any one sensor that is in occupied mode shall command all air terminals serving space into occupied mode.
   d. Occupied Mode:
3. Air flow Control
   a. Air flow control (Occupied Mode):
      1). DDC VAV controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
      2). DDC VAV controller shall utilize airflow sensors in room return or exhaust air terminal to continuously measure room return or exhaust airflow. DDC VAV controller shall continuously calculate required room return or exhaust airflow rate necessary to maintain predetermined offset, between total return or exhaust and supply airflows, by subtracting or adding offset (defined in supply air terminal device schedules) from/to total room supply airflow rate to determine return or exhaust airflow rate. Damper actuator (FLP) serving return or exhaust air terminal shall be modulated to maintain predetermined offset.
   b. Air flow control (Unoccupied Mode):
      1). Air flow to the space modulates to maintain unoccupied minimum air flow setpoint as indicated in schedules.
4. Temperature Control

a. Temperature Control (Occupied Mode):
   1). Electronic space temperature sensor through DDC VAV controller shall modulate damper actuator (FLP) on variable-volume supply air terminal and reheat coil control valve (FLP) in sequence to maintain space temperature setpoint. On a drop in space temperature below the cooling setpoint, supply air terminal shall modulate from maximum to minimum airflow rate as scheduled. On a continued drop in space temperature below the heating setpoint, reheat coil control valve shall modulate open to maintain temperature setpoint. On a rise in space temperature, the reverse shall occur.

b. Temperature Control (Unoccupied Mode):
   1). When space is unoccupied, temperature control shall operate the same as occupied mode incorporating a ±5°F (FA) offset in the space temperature setpoint.

H. Air Terminal Unit Control Sequence Number 5 - Variable Volume Supply with Reheat and Radiant Ceiling Panel, Supply/Return or Exhaust Air Tracking:
   1. General:
      a. Refer to detail 1 on drawing IC731
      b. Room consists of;
         1). Supply air terminal with reheat coil
         2). Radiant ceiling panel
         3). Return or exhaust air terminal(s)
   2. Occupied-Unoccupied Mode:
      a. Space shall have single operating mode. Consider space occupied at all times.
   3. Air flow control:
      a. DDC VAV controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
      b. DDC VAV controller shall utilize airflow sensors in room return or exhaust air terminal to continuously measure room return or exhaust airflow. DDC VAV controller shall continuously calculate required room return or exhaust airflow rate necessary to maintain predetermined offset, between total return or exhaust and supply airflows, by subtracting or adding offset (defined in supply air terminal device schedules) from/to total room supply airflow rate to determine return or exhaust airflow rate. Damper actuator (FLP) serving return or exhaust air terminal shall be modulated to maintain predetermined offset.
   4. Temperature Control:
      a. Electronic space temperature sensor through DDC VAV controller shall modulate damper actuator (FLP) on variable-volume supply air terminal, reheat coil control valve (FLP), and radiant ceiling panel control valve (FLP) in sequence to maintain space temperature setpoint. On a drop in space temperature below the cooling setpoint, supply air terminal shall modulate from maximum to minimum airflow rate as scheduled. On a continued drop in space temperature below the heating setpoint, reheat coil control valve and radiant ceiling panel control valve shall modulate open in sequence to maintain temperature setpoint. On a rise in space temperature, the reverse shall occur. Refer to FIN TUBE/ RADIANT CEILING PANEL – CONTROL SEQUENCE.

I. Air Terminal Unit Control Sequence Number 6 - Variable Volume Supply (Cooling Only):
   1. General:
      a. Refer to detail 2 on drawing IC731
      b. Room consists of;
         1). Supply air terminal

2. Occupied-Unoccupied Mode:
    a. Space shall have single operating mode. Consider space occupied at all times.
3. Air flow control:
    a. DDC Variable Air Volume (VAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate and modulate damper actuator to maintain air flow between occupied minimum and occupied maximum as indicated in air terminal schedules.
4. Temperature Control:
    a. Electronic space temperature sensor through DDC VAV controller shall modulate damper actuator (FLP) on variable-volume supply air terminal to maintain space temperature setpoint. On a drop in space temperature below the cooling setpoint, supply air terminal shall modulate from occupied maximum to occupied minimum airflow rate as scheduled. On a rise in space temperature, the reverse shall occur.

J. Air Terminal Unit Control Sequence Number 7 – Constant Volume Return/Exhaust:
1. General:
    a. Refer to detail 3 on drawing IC731
2. Room consists of;
    a. Return/Exhaust air terminal

K. FIN TUBE RADIATION / RADIANT CEILING PANEL - CONTROL SEQUENCE
1. A space thermostat shall modulate control valve (FLP) to each unit to maintain space temperature at setpoint.
2. Where fin tube radiation/radiant ceiling panel is shown in space with reheat coil, devices shall operate in sequence.
    a. Fin tube radiation/radiant ceiling panel valve shall open to 50% first before reheat coil valve starts to open and fin tube radiation/hydronic panel radiator valve shall be open 100% when reheat coil valve reaches 50% open. Refer to AIR TERMINAL DEVICES control sequence.

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SECTION 23-2116 PIPE AND PIPE FITTINGS

PART 1 GENERAL

1.1 RELATED WORK

A. Section 20-0529 – Piping and Equipment Supporting Devices.

B. Section 23-0594 - Water Systems Test Adjust Balance.

C. Section 23-0902 - Control Valves and Damper (Valves)

D. Section 23-0903 - Control Instrumentation

E. Section 23-2118 - Valves.

F. Section 23-2120 - Piping Specialties.

G. Section 23-2514 – Water Systems Chemical Treating

1.2 REFERENCE

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

1.3 DESCRIPTION

A. This Section includes pipe and pipe fitting specifications and installation requirements for heating and cooling systems.

B. Specification of an item in this or any other sections shall not relieve Contractor from providing all items, articles, materials, operations, methods, labor, equipment and incidentals necessary for a complete and functional system.

C. Use only new material, free of defects, rust and scale, and guarantee for services intended.

D. Use material meeting the latest revision of ASTM specifications as listed in this specification.

E. Follow local codes if they require other types of pipe or joints.

F. Use only long radius elbows having centerline radius of 1.5 pipe diameters unless otherwise indicated.

G. Manufacturer, pressure class, size and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.

H. Where size for a pipe segment is not indicated, the pipe segment size shall be equal to the largest pipe segment to which it is connected. Transition to smaller size shall occur on the side of fitting where smaller size is indicated.

I. Unless otherwise indicated, fittings and accessories connected to pipe shall be of the same material as the pipe.

J. Unless otherwise indicated, construct piping for highest pressures and temperatures in respective system in accordance with the latest revision of the applicable Sections of ASME Code for pressure piping, ASME B31 including the following:

1. B31.9 Building Services Piping
2. B31.1 Power Piping
3. B31.5 Refrigeration Piping

K. Non-metallic piping will be acceptable only for services indicated and with written approval from Owner. It will not be acceptable in occupied spaces and ventilation plenum spaces.

1.4 SUBMITTALS

A. Shop drawings for each piping system for all pipe sizes including, but not limited to, the following:

1. Name of system
2. Pipe; ASTM number, grade if known, type, wall thickness, material
3. Fittings; ASME number, grade if known, class, type, wall thickness, material
4. Joint type
5. Flanges; ASTM number, grade, class, type, material
6. Bolts and nuts; material
7. Thread joint sealants; material
8. Flange gaskets; material, rating
9. Unions; ASTM number, type, material, rating
10. Type of welding
11. Welding Quality Control Program
12. Test pressure and media
13. Pipe flushing procedures
14. Pipe cleaning method
15. All other appropriate data

B. Submit pipe certification as specified under Pipe Certification in this Section.

C. Submit required documents as specified under Pipe Welding in this Section.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and construction debris from accumulating inside of pipe.

B. Where possible, store materials inside and protect from weather. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.

C. Before shipping, all carbon steel piping shall be free of rust and scale, and furnished with plastic end caps/plugs on each end of pipe.

1.6 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. Quality Control Program:

1. Submit written quality control program for review and approval prior to implementing any welding on this project. Quality control program shall include the following as minimum:
   a. Explanation of how Contractor will assure proper fit up for each weld.
   b. Explanation of how Contractor will document welds performed by individual welding operators for systems under ASME B31.1.
   c. Explanation of how Contractor will assure that proper welding procedure is being followed.
   d. Credentials of personnel responsible for required weld examinations.

C. Weld Inspection and Examination:

1. Provide examination services for all welding for this project. Examination shall be in accordance with requirements of ASME B31.1, Table 136.4 or B31.9, as applicable. Personnel performing examinations shall comply with requirements stipulated in 136.1 (A) through (E) or shall be AWS QC1 certified.
2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.
3. Arrange with Owner's Inspector for observation of fit up and welding methods prior to implementing any welds, including shop welds, on this project.
4. In addition, Owner's Inspector will perform any additional observations deemed necessary before, during, or after fabrication to assure, to Owner's satisfaction, that proper welding is provided. Owner reserves the right to perform independent examination of welds. If Owner has any concern as a result of such examination Owner reserves the right to stop in progress welding work, without any cost to Owner, until resolution satisfactory to Owner is reached.

D. Welder Qualifications:

1. Each welder and welding operator must qualify by passing required procedure test before performing any project welds. Submit copy of Manufacturer's Record of Welder or Welding Operator Qualification Tests 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."

E. Weld Record:

1. For welding within the scope of ASME B31.1 Power Piping, submit to Engineer for approval an administrative procedure for recording, locating, monitoring and maintaining quality of welds to be performed on the project. This quality control document record shall include but not be limited to:
   a. Drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date, and WPS used.

1.7 PIPE CERTIFICATION

A. Certification is required for all pipe within scope of ASME B31.1. Submit certification papers, as outlined below, within 30 days of delivery of pipe to project site.

B. Type E or S Pipe:

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

1.8 CATHODIC PROTECTION

A. Cathodic protection shall be designed and provided by system pre-insulated pipe manufacturer for pipe systems as specified in Part 2. Cathodic protection shall conform to recognized practices and shall be designed by qualified personnel. Measurements of corrosivity of soil environment expressed in terms of soil's electrical resistivity (ohm/cm) shall be taken and checked out by pre-insulated pipe manufacturer. Resistivities shall be given along proposed routing of piping systems. Anodes and test stations shall be provided by, this Contractor as recommended by pre-insulated pipe manufacturer.

B. After installation, field survey, shall be made by, pre-fabricated pipe manufacturer and measurement of current and conduit-to-soil potentials at each test station shall be taken.

PART 2 PRODUCTS

2.1 LOW PRESSURE STEAM (15 psig and lower)

A. 2" and Smaller:

1. Pipe: ASTM A312, 304, Schedule 40S, 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. Refer to Unions and Flanges in this Section.

B. 2-1/2 inches and Larger:

1. Pipe: ASTM A312, 304, Schedule 40S, 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

2.2 LOW PRESSURE STEAM CONDENSATE (Steam Pressure 15 psig and Lower)

A. 2" and Smaller:

1. Pipe: ASTM A312, 304, Schedule 40S, 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. Refer to Unions and Flanges in this Section.

B. 2-1/2" and Larger:

1. Pipe: ASTM A312, 304, Schedule 40S, 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

2.3 HEATING HOT WATER

A. 5" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube.
2. Fittings: ASME B16.22, wrought copper solder joint.
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield.

4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for line sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 150, cast copper alloy.
6. Use solder joints for valves and piping specialties in copper piping.

B. 6" and Larger:

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

2.4 HEATING HOT WATER (AT AIR HANDER COILS)

A. 2" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube.
2. Fittings: ASME B16.22, wrought copper solder joint.
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield.
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for line sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 150, cast copper alloy.
6. Use solder joints for valves and piping specialties in copper piping.

B. 2-1/2" and Larger:

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

2.5 CHILLED WATER

A. 2" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube.
2. Fittings: ASME B16.22, wrought copper solder joint.
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield.
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for lines sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 250, cast copper alloy.
6. Use solder joints for valves and piping specialties in copper piping.

B. Contractor may use carbon steel as specified below in lieu of copper pipe for 2" and smaller.

1. Pipe: ASTM A53, Type F, standard weight, carbon steel.
2. Fittings: ASME B16.4, Class 125, cast iron, threaded or ASME B16.3, Class 150, malleable iron, threaded.
3. Unions: ASME B16.39, malleable iron, Class 250. Refer to Unions and Flanges in this Section.

C. 2-1/2" and larger:

1. Pipe: ASTM A53, Grade B, Type E or S, standard weight, carbon steel.
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld.
3. Flanges: Class 250. Refer to Unions and Flanges in this Section.

2.6 VENTS AND RELIEF VALVES

A. Use pipe and pipe fittings as indicated for the system to which relief valve or vent is connected.

B. Use ASTM A53, Type F, carbon steel with ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless carbon steel weld fittings for refrigerant vent piping.

2.7 PRESSURE GAUGES AND TAPPINGS

A. Use pipe and pipe fittings as indicated for the system to which pressure gauge or tapping is connected. Use "Threadolets", "Sockolets" or tee fittings for tappings. Refer to Part 3 under General for use of "Threadolets" and "Sockolets".

B. Gauge pipe shall be 1/4" unless otherwise indicated.

C. Gauge pipe shall be 1/2" for high pressure steam (101 psig and over) systems.

2.8 COOLING COIL CONDENSATE DRAIN

A. Piping shall be one of the following, unless otherwise indicated on drawings:

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

2.9 DIELECTRIC UNIONS, FLANGES AND FITTINGS

A. Copper to Steel Pipe:

1. 1" and Smaller: ASTM A197/ASME B16.3, 300 lb, WOG malleable insulating unions with vulcanized fiber insulating sleeve and neoprene gasket, equal to Stockham figure 693-1/2, or Epco model FX or FB dielectric unions with dielectric gasket, 250 psi at 210°F.
2. 1-1/2" and Larger: Epco model GX dielectric flange for 1-1/2" and 2" and model GWX for 2-1/2" and larger with dielectric gasket, 175 psi at 210°F.

2.10 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. 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. Unless otherwise indicated or recommended by manufacturer, gaskets shall be similar to Garlock IFG 5500 with 1/16" thick gasket.

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

D. Bolting:

1. Bolts, bolt studs, nuts and washers shall have zinc plated finish.

2. Thread shall be in accordance with ASME B1.1, Class 2A tolerance for external threads and Class 2B tolerance for internal threads. Threads shall be coarse-thread series except that alloy steel bolting 1-1/8" 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 at 400°F or lower temperature, use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B with nuts conforming to ASTM A307.

2.11 THREADED JOINT SEALANTS

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

B. Teflon tapes are not allowed.

2.12 CLEAN STEAM AND CONDENSATE (HUMIDIFICATION)

A. Use pipe and pipe fittings as indicated for associated steam and steam condensate specified in this Section.

PART 3 EXECUTION

3.1 GENERAL

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

B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Piping installed in shell spaces shall be routed tight to structure above in order to allow space for installation of fit-up related systems and equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other architectural details before installing piping.

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

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

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

F. "Weldolets" with outlet size 2-1/2" and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch takeoff up to one half (1/2) diameter of main. Use "Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Materials of "Weldolets", "Threadolets" and "Sockolets" shall match material of piping.

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

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

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

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

K. For piping within the scope of ASME B31.1 Power Piping, transfer piping material specification and "Heat Number" to each segment of pipe prior to cutting.

3.2 THREADED PIPE JOINTS

A. Threads of pipe and fittings shall conform to ASME B1.20.1.

B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.3 FLANGED JOINTS

A. Clean flange surfaces and align them parallel. Bolt holes of gaskets shall be cut slightly larger than bolt diameter. Gasket ID shall be slightly larger than flange ID.

B. Position gasket concentrically so compression is equally distributed over entire gasket surface.

C. Lubricate bolts and run nuts down by hand.

D. By using torque wrench, tighten nuts in the proper sequence so gasket is compressed evenly, and to the appropriate torque specified by bolt manufacturer.

E. Re-torque bolts 12 to 24 hours after start up.

3.4 WELDED PIPE JOINTS

A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.

B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.

C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 60°F before welding.

D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.

E. Use weld material diameter as procedurally required for type and thickness of work being done.

F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.

G. Properly store welding materials.

H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.

I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.

J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.

K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.

L. Conduct radiographic test for sections or joints that cannot be tested by hydrostatic test methods (such as joints cut into existing piping systems) by qualified radiographic testing firm.

3.5 COPPER PIPE JOINTS

A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.

B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.

3.6 STEAM AND STEAM CONDENSATE

A. Pitch steam mains down at 1" per 40 ft in direction of flow. Pitch runouts to terminal equipment and control valves at 1/2" per 1 ft for proper condensate drainage. Install drip traps at each rise and at horizontal termination of each steam main.

B. Pitch steam condensate lines down at 1" per 20 ft in direction of flow.

C. Unless otherwise indicated, use eccentric fittings for changes in horizontal pipe sizes with fittings installed for proper condensate drainage (bottom of pipe straight). Concentric fittings may be used for changes in vertical pipe sizes.

D. For steam branch connections and runouts, use top or top 45° connection to main.

E. For condensate branch connections to condensate mains, use top or top 45° connection to main.

F. For condensate connections from steam mains, use bottom connection to main.

G. Install minimum of 3 elbows in each pipe run out to terminal equipment to provide flexibility for expansion and contraction of piping system.

3.7 CHILLED WATER SYSTEM

A. All chilled water system piping and associated components shall be designed, tested, and installed to support 250 psig system pressure.

3.8 WATER SYSTEMS

A. Pitch horizontal mains up at 1" per 40 ft in direction of flow. Install manual air vents at all high points where air may collect. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.

B. Main branches and runouts to terminal equipment may be made at top, side or bottom of main provided that there are drain valves suitably located for complete system drainage and manual air vents are located as described above.

C. Unless otherwise indicated, for upfeed risers, use top or top 45° connection to main and for downfeed risers use side or bottom 45° connection to main. If side or bottom 45° connection is not practical and bottom connection to main must be used, provide line size Y strainer with shut-off valve at each side at branch connection.

D. Use minimum of 3 elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems.

E. Use eccentric fittings for changes in pipe sizes and for valves smaller than pipe sizes, in horizontal lines, with fittings installed for proper air venting (top of pipe straight). Concentric fittings may be used for changes in pipe sizes and for valves smaller than pipe sizes in vertical lines.

F. Where mechanically formed tee fittings are allowed, form mechanically extracted collars in continuous operation, consisting of drilling pilot hole and drawing out tube surface to form collar having height of not less than 3 times thickness of tube wall. Collaring device to be adjustable.

G. Notch and dimple branch tubes. Braze joints. Apply heat properly so that pipe and tee do not distort. Remove distorted connections.

3.9 VENTS AND RELIEF VALVES

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

3.10 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.

3.11 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.

3.12 UNIONS AND FLANGES

A. Unions are not required on copper piping with soldered joints for 1/2" and 3/4" line sizes. Unions are required for line sizes 1" and larger.

B. 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.

C. Concealed unions or flanges are not allowed.

3.13 PIPING SYSTEM PRESSURE TESTS

A. Owner and/or Owner's representative may elect to witness pressure test. Notify Owner and/or Owner's representative at least 3 days in advance.

B. Conduct pressure test prior to flushing and cleaning of piping systems.

C. Conduct hydrostatic (HYDRO) test in accordance with ASME B31.1 137.4. Test pressure shall be in accordance with ASME B31.1, but shall not be lower than the minimum test pressure listed below.

D. If leaks are found, repair with new materials and repeat test until leaks are eliminated. Caulking will not be acceptable.

E. Pressure tests may be made of isolated portions of piping systems to facilitate general progress of installation. Any revisions made in piping systems require retesting of affected portions of piping systems.

F. No systems shall be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Unless otherwise noted, minimum test time shall be 4 hrs plus such additional time as may be necessary to conduct examination for leakage.

G. No pressure drop shall occur during test period. Any pressure drop during test period indicates leakage.

H. Provide pumps, gauges, instruments, test equipment, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.

I. For hydrostatic tests, remove air from piping being tested by means of air vents. Measure and record test pressure at high point in system. Where test pressure at high point in system causes excessive pressure at low point in system due to static head, portions of piping system may be isolated and tested separately to avoid undue pressure. However, every portion of piping system must be tested at the specified minimum test pressure.

J. Conduct pressure tests with parameters indicated below:

System	Minimum Test Pressure	Remarks
Low pressure steam and condensate	75 psig	HYDRO
Steam condensate pump discharge	150 psig	HYDRO
Heating hot water	150 psig	HYDRO
Chilled water	300 psig	HYDRO

K. Contractor shall provide all pumps, gauges, instruments; test equipment, flow meters, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.

L. If piping system is drained after testing and left empty or untreated for more than 3 days, add Nalco 2572 at recommended dosages for dry system lay-up.

3.14 FLUSHING AND CLEANING PIPING SYSTEMS

A. Provide flushing and drain connections for complete flushing and drainage of entire system.

B. Flush new water, steam and condensate systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system. Bypass pumps and equipment, open all valves and remove strainers from strainer bodies. Provide circulation by Contractor-supplied portable pumping apparatus. Flush with clean domestic water.

C. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory-cleaned equipment, and any component that may be damaged, unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.

D. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottoms of risers.

E. For pipes 18" and larger, maintain velocity as close as 6 fps possible, but not below 5 fps.

F. After initial flushing of system, use portable pumping apparatus to circulate cold water detergent for water systems. Refer to Section 23 2514 - Chemical Treatment Systems for pipe cleaning.

G. Refer to Section 23-2514 - Chemical Treatment Systems for water analysis.

H. Flush compressed air piping with clean, dry compressed air for one (1) hour minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.

I. For clean steam system, flush as indicated above followed by passivation in accordance with ASTM A380. Flush with purified water followed by 4 hours with clean steam and wasting all condensate. Clean steam generator shall be valved out of system except when clean steam is generated. Submit results of passivation to Engineer.

3.15 INITIAL SYSTEM FILL AND VENT

A. Fill and vent systems with proper working fluids.

B. Use fluids chemically treated as specified in Section 23-2514 - Chemical Treatment Systems.

3.16 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 2118 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 2120 - Piping Specialties (Flow Sensors and Meters)

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 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 MANUFACTURERS

A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.

B. Other valves: acceptable manufacturers and Figure Number listed under each item.

C. Butterfly valves and check valves manufactured by grooved coupling manufacturer will be acceptable where grooved pipe connection system is allowed, provided valves meet requirements specified in this section.

2.2 WATER SYSTEM VALVES

A. General:
   1. Valves 2" and smaller in steel piping shall have threaded ends.
   2. Valves 2" and smaller in copper piping shall have solder ends.
   3. Valves within reheat piping systems shall have threaded ends.

4. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.
5. All chilled water piping valves shall be rated to 250 psig WOG working pressure at 100°F.

B. Ball Valves:
1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port for 3/4" and smaller and conventional port for 1" and larger, Teflon seat rings, blowout-proof stem, 2-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T(S)-580-70, Apollo No. 70, Watts, Milwaukee BA-150, Hammond, FNW or Anvil

C. Spring Loaded Check Valves:
1. 2" and Smaller: bronze or iron body, Class 125 (200 psi WOG), Nibco Figure T(S)-480, Mueller Figure 303-AP or Metraflex No. 700
2. 2-1/2" and Larger: cast iron or ductile iron body, flanged or wafer type, 302/304 or 316 stainless steel spring, aluminum bronze, carbon steel or ductile iron totally encapsulated in EPDM disc, Buna-N or electroless nickel plated seat, Class 125 (200 psi WOG), Nibco Figure F-910 or W-910, Milwaukee 1800 or 1400, Metraflex No. 700, Stockham Figure WG-970, Mueller Sure Check Model No. 71, or Crane Duo-check II
3. For valves 8" and larger, provide lifting lugs or threaded holes for lifting eye bolts.

D. Shut-Off Valves:
1. 2" and Smaller: ball valves as specified in this Section
2. 2-1/2" and Larger: butterfly valves as specified in this Section

E. Balancing Valves:
1. 2" and Smaller: calibrated balancing valves:
   a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour & Andersson (Victaulic) Series 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by IMI Flow Design, Hays, Nexus, HCi or Taco. Bronze or brass body, 250 psi maximum working pressure, 250°F maximum operating temperature. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
   b. Valves shall measure down to 0.3 gpm with accuracy of ±5%.
   c. Valves shall be leak-tight at full rated working pressure.
   d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.
2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson (Victaulic) Series 788/789, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature. Fixed orifice with ball valve or butterfly valve as manufactured by FDI, Presco or Gerand, Class 150 flange, 225 psi maximum working pressure, 250°F maximum operating temperature will be acceptable up to 4" size. Butterfly valves, as specified in this Section, together with averaging Pitot tube flow sensors, as specified in Section 23 2120 - Piping Specialties, under Flow Sensors and Meters may be used when sizes for Armstrong or T/A valves are not available. Locate flow sensor in common pump discharge pipe with hot tap. Furnish butterfly valves with adjustable memory stops to limit return of valves to preset open position after shut-off.
3. Furnish portable meter kit within durable case similar to Gerand Model "R". Furnish meter with minimum 4-1/2" diameter aluminum or brass body/brass internals with reading range of either 0" to 50" or 0" to 100" water column differential as appropriate, 200°F maximum temperature, 300 psi

working pressure. Meter accuracy shall be ± 2% full scale. Provide in kit: equalizing valves, 10 ftpurge hose and size devices specified. Meter shall become property of Owner.

4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

F. Terminal Unit Valve Assembly

1. Terminal unit valve assembly may be used instead of individual valve and other components, provided each valve and component meets specified requirements.
2. Victaulic, Nexus, Griswold, HCi, IMI Flow Design or Hays are acceptable.
3. Inlet Assembly: combination of isolation ball valve, y-strainer with 20 mesh SS screen and blowdown valve, union, and PT test port.
5. Components: Assembly shall have minimum pressure/temperature ratings to 400 psi230°F

G. Butterfly Valves:

1. 2-1/2" and Larger:
    a. Manufacturers: DeZurik, Keystone, Nibco, Milwaukee, or Bray
    b. Ductile iron body, stainless steel shaft, aluminum-bronze disc, or Nylon 11 coated ductile iron disc, upper thrust bearing, EPDM resilient seat, rated at 200 psi bidirectional shut-off pressure, suitable for continuous operation at temperature up to 225°F, compatible to ANSI B16.1 Class 125/150 flange standards, conforming to MSS-SP-67.
    c. Dead end pressure rating shall be 150 psi with no downstream flange/piping attached.
    d. For valves 6" and smaller, provide 10-position lever actuators with locking devices. For valves 8" and larger, provide rotary hand wheel operators with adjustable position stop and position indicators. Size hand wheel operators with no higher than 80 lb rim pull at full valve pressure rating.
    e. External disc-to-stem connections using screws or pins are not allowed.
    f. Valve necks shall be of sufficient length to allow for insulation where insulation is specified. Wheel shaft shall be sufficient length so wheel does not touch insulation.
    g. Provide full lug type valves permitting removal of down stream piping while using valve for system shut-off.
    h. Furnish valves used for balancing with adjustable memory stops.

H. Water Pressure Regulating Valves:

1. Manufacturers: Thrush, Watts, Cash-Acme, Taco, or B & G
2. Brass or bronze body, spring and diaphragm operated, pressure adjustable with check valve and inlet strainer and designed for maximum working pressure 125 psig and maximum operating temperature of 160°F.

I. Lockshield Valves:

1. Ball valves as specified above with locking handles for padlocking in open or closed position.

J. 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.

K. Combination Shut-off, Check and Balancing Valves:

1. 2-1/2" and larger - cast iron or semi-steel body, flanged, stainless steel stem and spring, replaceable bronze disc with EPDM seat, calibrated balancing adjustment with memory bank, backseating valve stem, maximum working pressure of 175 psi at 250°F, Bell and Gossett, Thrush-Amtrol, Armstrong or Taco.

2. Valve design to be straight pattern unless otherwise indicated and constructed to permit repacking under full line pressure.
3. Valves to be equipped with brass readout valves with integral check valve for taking differential pressure readings across orifice.

2.3 STAINLESS STEEL VALVES (HUMIDIFICATION STEAN AND CONDENSATE)

A. Gate Valves:
   1. 2 and Smaller: stainless steel body, flanged, stainless steel solid wedge, stellite seats, rising stem, union bonnet, malleable iron handwheel, impregnated teflon packing, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S15F6-316
   2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel solid wedge, stellite seats, impregnated teflon packing, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S15F6-316

B. Globe Valves:
   1. 2" and Smaller: stainless steel body, flanged, stainless steel disc, stellite seats, impregnated teflon packing, union or screw-over bonnet, malleable iron handwheel, Class 150 (150 psi WP steam), Williams, Velan or Powell equal to Williams Fig. S152F6-316
   2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel disc, stellite seats, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S152F6-316

C. Swing Check Valves:
   1. 2" and Smaller: stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S151F6-316
   2. 2-1/2" and Larger: stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Fig. S151F6-316

D. Drain Valves:
   1. Gate valve as specified above with hose thread adapter. Provide 3/4" minimum drain valve size except strainer blowdown valves to be blowdown connection size.

2.4 CHAIN WHEEL OPERATORS

A. Similar to Babbitt cast iron or ductile iron adjustable sprocket rims and chain guides. Use galvanized or brass chain and chain closure links to form continuous loop of chain at each operator.

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. Provide chain operators for manually operated valves 4" and larger, located more than 8 ft above equipment room floor.

3.2 SHUT-OFF VALVES

A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.

B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.3 BALANCING VALVES

A. Provide balancing valves where indicated on drawings and as required for complete balancing of water systems.

B. Provide straight inlet and outlet pipe length in accordance with manufacturer's recommendation.

C. Balancing valve at pump discharge line is not required where pump is driven by variable frequency drive (VFD).

D. For buildings with multiple stories, provide balancing valve in return line at riser take-offs at each floor. Provide shut off valve in supply line at each riser take-off.

3.4 GAUGE VALVES

A. Provide gauge valves at each pressure gauge as shown and at each pressure tapping where pressure sensing tubing is connected.

3.5 DRAIN VALVES

A. Provide drain valves at all low points of piping systems for complete drainage of systems.

B. Unless otherwise indicated, provide 1/2" drain valve for 1/2" piping and minimum 3/4" drain valve for 3/4" and larger piping, except strainer blowdown valves shall be blowdown connection size.

3.6 WATER PRESSURE REGULATING VALVES

A. Set valves for pressure required or as scheduled.

3.7 WATER RELIEF VALVES

A. Unless otherwise indicated, provide one relief valve in each closed water system in the pump inlet piping.

3.8 SPRING LOADED CHECK VALVES

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

3.9 SWING CHECK VALVES

A. Provide swing check valves at steam condensate lines if lifted at outlet of traps. Install check valve between trap and gate valve.

B. Install check valves in horizontal piping.

3.10 COMBINATION SHUT-OFF, CHECK AND BALANCING VALVES

A. Contractor may provide combination shut-off, check and balancing valve in lieu of providing separate shut-off valve, check valve and balancing valve in pump discharge line.

END OF SECTION

SECTION 23-2120 PIPING SPECIALTIES

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

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

1.3 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.

1.4 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 THERMOMETERS

A. Manufacturers: Taylor, Trerice, Weksler, MILJOCO, Jay, or Weiss.

B. Pipeline mounted thermometers - 9" scale cast aluminum case and frame, clear acrylic plastic window front, permanently stabilized glass tube with mercury free indicating fluid, adjustable angle stem, extended neck suitable for insulated piping as required, and compatible with sockets as specified herein.

C. Panel or remote mounted thermometers: vapor actuated dial type with remote bulb, 4-1/2" minimum diameter cast metal casing with double front. Sensing bulbs shall be of length to suit pipe diameter with extended necks as required for insulated piping, suitable for insertion in separable brass sockets as specified herein.

D. Duct type thermometers: dial type with minimum dial size of 4-1/2" and maximum graduations of 2°F, complete with swivel mounting arrangement to permit up to 45 degrees rotation for easy reading.

E. Range of thermometers shall be:

Service	Scale Range	Increment
Chilled Water	0°F to 100°F	1°F
Heating Hot Water	30°F to 240°F	2°F
Steam / Steam Condensate	30°F to 300°F	2°F
Air (indoor)	0°F to 160°F	2°F
Air (outdoor)	-40°F to 100°F	2°F

F. Thermometers by temperature control manufacturer meeting above specification will be acceptable.

2.3 THERMOMETER SOCKETS AND TEST WELLS

A. Brass construction for carbon steel piping 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 or approved equal.

B. For test wells for stainless steel piping, use same material as piping.

2.4 PRESSURE GAUGES

A. Manufacturers: Ashcroft, U.S. Gauge, Marsh, Taylor, Trerice, MILJOCO, Marshalltown, or Weiss equal to Trerice 600 Series.

B. Minimum 4-1/2" diameter die cast aluminum case, glass or acrylic plastic window, phosphor bronze bourdon tube with bronze bushed movement, recalibration from front of gauge dial and 1/4" NPT forged brass socket.

C. Gauge accuracy shall meet ANSI B40.1 Grade A (1% full scale).

D. Reading range of gauges shall be:

Service	Scale Range
Chilled Water	0 to 100 psig
Heating Hot Water	0 to 100 psig
Low Pressure Steam	30" mercury vacuum to 30 psig
Steam Condensate Pump Discharge	Range to be appropriate for specific pump head selected, but not less than 0 to 100 psig

E. Pressure Snubbers:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings, 1000 psig WP. Brass for carbon steel pipe or copper pipe. Stainless steel for stainless steel pipe.

F. Coil Syphons:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116, 500 psig WP. Material shall match gauge pipe material.

2.5 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plugs made by Peterson Equipment Company, Sisco, Super Seal by Flow Design Inc. (FDI), or approved equal.

B. Test plugs shall be 1/4" or 1/2" NPT, brass body and cap, 1-1/2" length for non-insulated pipe and 3" length for insulated pipe, with Nordel self-closing valve cores, rated at 500 psig at 275°F, and shall receive either temperature or pressure probe with1/8" OD.

C. Furnish portable test kit within durable case containing the following:

1. A compound pressure gauge, 3-1/2" dial, 30" Hg - 100 psi, field calibration screw, surge protector and stainless steel gauge adapter with 1/8" diameter probe (2% accuracy of mid range).

2. Two pocket testing thermometers, 1-3/4" dial, 5" long stainless steel stem, 0 - 220°F and 25 -125°F ranges with external calibration (1/2% accuracy of entire scale).

2.6 PIPELINE STRAINERS

A. Manufacturers: Metraflex, Mueller Steam Specialty, Hoffman, Hayward, Sarco, Keckley, Armstrong, Wheatley, Conbraco or Streamflo.

B. Liquid System:

1. 2" and Smaller: full pipeline size, "Y" type, with removable screen caps, cast iron, 250 psi WP, threaded ends for carbon steel piping and bronze, solder ends for copper piping. Screen caps shall have threaded blowdown connection.

2. 2-1/2" and Larger: full pipeline size, "Y" type, Class 300, cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.

3. Liquid Service Screens: stainless steel with screen perforation as indicated below. Maximum pressure drop shall be 4 ft WG through clean strainer.

Pipe Size	Closed System	Open System
2" and smaller	1/32" (20 mesh)	1/8"
2 1/2" to 4"	1/16"	1/8"
5" and over	1/8"	1/8"

C. Steam and Condensate System (through 14 psig):

1. 2" and Smaller: full pipeline size, Y-type, Class 250, stainless steel, threaded ends with removable screen caps. Screen caps shall have threaded blowdown connection.

2. 2-1/2" and Larger: full pipeline size, Y-Type, Class 125, stainless steel, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.

D. Steam Service Screens: stainless steel for low pressure and monel for high pressure with screen perforation size as indicated below. Net area of screen shall be at least 4 times that of connected pipe.

Pipe Size	Perforation Size
2" and smaller	1/50" (30 mesh)
2 -1/2" to 10"	3/64" (.045")
12" and over	1/16" (.062")

2.7 STEAM TRAPS

A. Manufacturers: Armstrong, Sarco, Hoffman, Watson McDaniel, MEPCO, or Watts (Illinois).

B. Trap bodies and trim shall be suitable for pressure classification of system in which they are used, but not less than 125 psig allowable pressure for low pressure steam system and 175 psig allowable pressure for float and thermostatic traps and 300 psig allowable pressure for inverted bucket traps for high pressure steam system.

C. Traps shall have threaded end connections.

D. Unless otherwise indicated, determine trap capacity with the following safety factor, differential pressure and steam pressure at apparatus inlet. Minimum trap size (pipe connection size) shall be 3/4" for all types.

1. Apply safety factor to maximum steam rate of apparatus served and at saturated steam temperature.
2. 0-15 psig steam:
   a. Safety factor of 2:1 at 1/2-psi pressure differential

E. Size main drip, end-of-main or drip-and-rise traps with 2:1 safety factor at full differential pressure for supervised warm-up load, but not less than 250 lb per hour and not smaller than 3/4" size.

F. Where 2 traps are shown in parallel, each trap shall have full design capacity of equipment without safety factor.

G. Float and Thermostatic Traps:

1. Stainless steel body with removable cover, stainless steel float, diaphragm or bellows thermostatic operator, and stainless steel valve mechanism.

H. Inverted Bucket Traps:

1. Stainless steel body with removable cover, stainless steel bucket, and stainless steel valve mechanism assembly.

2.8 AIR VENTS

A. Manual Air Vents:

1. Manufacturers: Hoffman, Watson McDaniel, similar to Bell & Gossett Model 4V, 125 psig at 210°F. Use 1/2" ball valve for main pipes. Chilled water system air vents shall be rated to 250 psig.

2.9 VACUUM RELIEF/BREAKERS

A. Armstrong, Kadant Johnson Series VB-8 with brass body, stainless steel ball, EPR seat, stainless steel spring, suitable for pressures to 300 psig at 365°F, or Bell and Gossett Model No. 26, 150 psig at 240°F.

2.10 FLOW SENSORS AND METERS

A. Averaging Pitot Tube Flow Sensors (2-1/2" and Larger):

1. Manufacturers: Dieterich Standard, Taco Sentinel, or Preso.
2. Sensors shall be averaging differential pressure type consisting of sensing tube with 2 internal chambers; one for sensing upstream pressure and one for sensing downstream pressure.
3. Furnish each flow measuring station complete with safety shut-off valves, quick coupling connections and permanent metal tag showing designed flow rates, meter readings for designed flow rates, metered fluid, line size and tag, station or location number. Annular measuring element shall be constructed of stainless steel. Stations shall be nipple section or weld insert type and be rated to 250 psi at 250°F.
4. Hot tap type flow stations shall include isolation valve and packing gland retraction assembly. Connection shall be flange type. Station shall be rated to 250 psi at 250°F.
5. Portable differential pressure meter set shall be of totally dry single diaphragm type with min. 4-1/2" dial pointer indicator, 0" to 50" reading range, accuracy of ± 3.0% full scale, and wetted metal parts of brass or stainless steel. Meter shall include variable pulsation dampening control, integral equalizing valve, and 2 bleed valves.
6. Furnish meter set complete with master chart for direct conversion of meter readings to gpm, rust proof carrying case, two minimum 10 ft rubber test hoses, with brass valves for quick connections to flow sensor. Meter shall become property of Owner.
7. Furnish elbow mounted Pitot tube measuring stations at locations where manufacturer's recommended straight pipe lengths are not available for straight pipe mounted measuring stations.

B. Venturi Flow Sensors:

1. Manufacturers: Barco, Gerand, or Preso.
2. Sensors shall be flanged ends for 2-1/2" and larger and threaded ends 2" and smaller. Furnish tubes with quick disconnect taps and shut off valves, suitable for 125 psi WP. Select tubes for size and pressure drop as scheduled and tag for mark number, flow and pressure drop as specified.
3. Provide portable meter kit within durable case. Furnish with 6" diameter forged brass meter having dial range from 0" to 50" WG. Provide in kit equalizing valves, vent hose and size devices specified. Meter shall become property of Owner.
4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

2.11 STRAIGHTENING VANES

A. Straightening vane assembly shall consist of series of carbon steel pipes firmly welded together and to line size pipe. Furnish vanes with class 150 psi flanges for insertion into piping system.

PART 3 EXECUTION

3.1 GENERAL

A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.2 PIPELINE STRAINERS

A. Provide drain valve at each strainer blowdown connection with hose threaded adapter and cap. Valve size shall be same as blowdown connection size.

B. Install strainers in steam system on entering side of all automatic control valves and as indicated elsewhere.

C. Install strainers in water systems on suction side of all pumps, entering side of automatic control valves of heating and cooling coils of air handling units, and as indicated elsewhere.

3.3 STEAM TRAPS

A. Install steam traps on discharge side of all steam using terminal apparatus, at steam headers, at steam mains, at end of steam mains, at end of branch piping exceeding 10 ft, at points where steam piping must rise, and elsewhere as indicated on drawings. Individually trap each coil of steam coil bank. Unless otherwise indicated, provide steam main drip/traps at intervals not exceeding 200 ft.

B. Install to permit gravity flow of condensate to trap.

C. Install valved test tee on discharge of each trap.

D. Unless otherwise shown, do not lift condensate from discharge of any trap without written permission of Engineer.

E. Support traps weighing over 25 pounds independently of connecting piping.

3.4 THERMOMETERS

A. Install thermometers in thermowells sockets in locations indicated.

3.5 THERMOMETER TEST WELLS

A. Install test wells in locations as shown and at each point where temperature-sensing device is required under Control Systems.

3.6 PRESSURE GAUGES

A. Install gauges for services other than steam with pressure snubbers and gauge valves.

B. Install gauges for steam service with coil syphons and gauge valves.

3.7 PRESSURE GAUGE TAPPING

A. Install tappings at each point where sensing device is required under Control Systems and at gauge locations as shown.

B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.8 PRESSURE/TEMPERATURE TEST STATIONS

A. Pete's plug may be used in lieu of thermometer test well and pressure gauge tappings.

B. Use threadolets or tee fittings to mount gauge tappings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.9 AIR VENTS

A. Install manual air vents at all high points in water systems where air may collect and where shown on drawings.

B. 1/2” ball valves may be used. All inaccessible air vents shall be piped down to an accessible location with additional user ball valve and capped hose connection. Valve at the main shall be normally open.

3.10 VACUUM BREAKERS

A. Install vacuum breakers at steam condensate outlet from steam heating coils, at steam-to-water heat exchangers, and as required for proper condensate drainage at any other steam using apparatus.

3.11 FLOW SENSORS/FLOWMETERS

A. Flow sensors located in common piping after multiple pump discharge lines shall be furnished with hot tap feature.

B. If flow sensors/flowmeters are furnished by Control Contractor, this Contractor shall install them in accordance with manufacturer's installation instructions. Wiring of flowmeters will be provided by, Control Contractor.

3.12 STRAIGHTENING VANES

A. Provide straightening vanes where flow sensor manufacturer's installation instructions require greater length of straight upstream piping than can be obtained in available space.

END OF SECTION

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SECTION 23-2123 PUMPS

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 23-2120 - Piping Specialties

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning 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. Pump curves with operating point clearly indicated. For parallel pump applications, indicate operating point of combined case as well as operating point of only one pump.
5. Motor data (refer to Section 20-0513 - Motors)
6. Seals
7. Materials of construction
8. Dimensions and weights
9. Manufacturer's installation instructions
10. All other appropriate data

1.4 DESIGN CRITERIA

A. Pump sizes, capacities, pressures and operating characteristics shall be as scheduled.

B. Pumps shall meet or exceed operating efficiencies scheduled.

C. Furnish pumps complete with motors, impellers, drive assemblies, bearings and accessories as hereinafter specified. Furnish pump couplings with OSHA compliant coupling guards.

D. Where pump is indicated for parallel operation, scheduled conditions are for that pump with two pumps operating; i.e., total system flow rate is twice that scheduled for single pump. When only one of two pumps is operating, operating point of that pump must fall within manufacturer's recommended operating range.

E. Select motor with sufficient horsepower rating for non-overloading operation over entire pump curve.

F. Furnish each pump and motor with nameplate giving manufacturer's name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current.

G. Test pumps hydraulically at 150% of rated pressure per Hydraulic Institute Standards, clean and paint before shipment. Manufacturer shall certify all pump ratings.

H. Pumps shall operate without objectionable noise or vibration.

I. After completion of balancing, if water balancing results in pump discharge balancing valve being closed 50% or more, replace or trim impeller so that balancing valve is opened at least 75% to maintain design flow rate. Where pumps are driven by VFDs, balancing should be performed with pumps at design speed.

J. Furnish one spare seal for each pump to Owner.

K. Head for pumps submitted for pumping through evaporators and condensers of chillers and water coils shall be increased, if necessary, to match the equipment approved for project.

PART 2 PRODUCTS

2.1 IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Bell and Gossett, Taco or Armstrong.

B. Pumps shall be pipeline mounted, single suction type with cast iron casing, bronze fitted with working pressure of 175 psi, continuous operating temperature of 225°F, and minimum test pressure of 250 psi.

C. Casings shall have tapped and plugged openings for vent, drain, and suction and discharge gauge connections.

D. Impellers to be single suction enclosed type made of bronze, hydraulically and dynamically balanced, keyed and locked to pump shafts and protected by replaceable bronze shaft sleeves.

E. Impellers shall be directly hung from motor shafts without using flexible couplings.

F. Pump shafts shall be high strength carbon steel or alloy steel, sealed and gasketed from pumped fluid.

G. Pumps shall be furnished with mechanical seals of single unbalanced type with carbon rotating faces, ceramic stationary seats and Buna-N elastomer.

H. Bearing assemblies and motors shall have oil lubricated sleeve bearings or regreasable ball bearings.

2.2 CONDENSATE PUMP UNITS

A. Manufacturers: Shipco or approved equal to the manufacturer's model scheduled.

B. Pumps shall be tank mounted or vertical basin mounted as scheduled complete with centrifugal type pumps, receiver and factory installed and wired operating and safety controls.

C. Unit shall be factory tested as complete unit and shall have single power connecting point.

D. Tank mounted pumps shall have cast iron casing, bronze fitted, stainless or high strength carbon steel shaft, mechanical type shaft seals. Pumps shall be close-coupled and flange mounted on receiver.

E. Receiver shall be steel suitable for steam condensate (212 ^{0}F) and shall have tappings or openings for pump suction, condensate inlet and vent.

F. Units with single phase motors shall be furnished with hand-off-automatic selection switches and externally adjustable float operated switches.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install pumps in strict accordance with manufacturer's instructions to avoid any stress and misalignment.

B. Install full line size spring loaded check valve and balancing valve in pump discharge piping.

C. Where pump connection size and indicated line sizes are not identical, provide necessary concentric reducers/increasers for vertical piping at pump connection and eccentric reducers/increasers for horizontal piping at pump connection. Install eccentric reducers/increasers with top of pipe level. Valves and piping specialties shall be full line size as indicated on drawings.

3.2 STARTUP

A. Verify that piping system has been flushed, cleaned and filled.

B. Prime pump, vent air from casing and verify that rotation is correct. To avoid damage to mechanical seals, never start or run pump in dry condition.

C. After several days' operation, verify removal of disposable startup strainer in suction diffuser and turn them over to Owner.

D. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23-0550 - Vibration Isolation.

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

Pump Data Sheet

General

- Project _____
- Identification _____
- Service _____
- Location _____
- Type _____
- Manufacturer _____
- Model Number _____

Performance

- Capacity (Flow) _____
- Head (Feet) _____
- Max. Net Positive Suction Head Req. (Feet) _____
- Efficiency (%) _____
- Horsepower required for non-overloading operation over entire pump curve _____

Physical Characteristics

- Suction Size _____
- Discharge Size _____
- Casing Material _____
- Impeller Material _____
- Shaft Sleeve Material _____
- Shaft Material _____
- Seal Type _____
- Seal Face Material _____
- Seal Seat Material _____
- Bearing Assembly Material _____
- Working Pressure & Continuous Operating Temp. _____
- Maximum Intermittent Temperature _____

Motor

- Manufacturer _____
- Horsepower _____
- Voltage _____
- Phase _____
- Hertz _____
- RPM _____
- Motor Type _____
- Enclosure Type _____
- Frame Type _____
- Insulation Class _____
- NEMA Design Designation _____
- Service Factor _____
- Nominal Efficiency _____
- Nominal Power Factor _____
- Full Load Amps _____
- Variable Frequency Drive Driven (Yes or No) _____

Miscellaneous

SECTION 23 2514 WATER SYSTEMS CHEMICAL TREATING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0993 - Control Sequences

B. Section 23 2116 - Pipe and Pipe Fittings

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. Chemicals; description of chemicals, its composition and function

B. Submit directly to Owner, Material Safety Data Sheets (MSDS) for all chemicals used in chemical treatment systems. Include with MSDS written notice of Owner's responsibility to notify its employees of the use of those chemicals.

1.4 WATER ANALYSIS

A. Submit complete water analysis.

B. Water analysis shall include the following:
   1. Hot and/or Chilled Water:
      a. Hardness
      b. pH
      c. M" alkalinity
      d. Inhibitor level
      e. Total dissolved solids
      f. Temperature
   2. Glycol Water:
      a. Corrosion inhibitor level
      b. Percentage of glycol by volume
      c. Freeze point
      d. "M" alkalinity
      e. Conductivity
      f. Test data for dilution water including total dissolved hardness and conductivity. (If on-site deionizer is used for dilution water, provide test of initial and final water coming from deionizer.)

1.5 WATER QUALITY REQUIREMENTS

A. The following levels of chemicals are to be maintained in the respective systems:
   1. Heating hot water – 200 ppm of Molybdate
   2. Glycol systems – 50% Ethylene glycol

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
   1. GE Water & Process Technologies (formerly Betz-Dearborn)
   2. Bluegrass KESCO

PART 3 - EXECUTION

3.1 PROCEDURE

A. Outage is scheduled with the Physical Plant Division – Medical Center (PPDMC) using the standard outage procedure.

B. A pre-test is conducted on the system to determine the chemical content prior to the work to establish an existing baseline. If this outage and work will be an extended period of time with the affected work portion being isolated from the remainder of the system, then this pre-test should occur approximately 48 hours prior to the refilling of the system. This pre-test should have the involvement of the PPDMC Preventative Maintenance Manager or his designee to agree on the baseline.

C. Outage is initiated by PPDMC and the contractor does the required work (additions, modifications or repairs) to the affected system.

D. Upon completion of the work, the contractor is to clean and flush the affected piping systems per the procedure outlined in the project specifications.

E. When the system is adequately cleaned and flushed, the contractor is responsible for refilling the section of the affected piping with water and appropriate chemicals to meet the required levels noted above.

F. After the outage section is filled, the affected area will be opened up back into the overall system by PPDMC.

G. The system will be allowed to operate normally and circulate throughout the system for 48 hours.

H. The chemical levels will be tested in the mechanical room that contains the system equipment and also in the area where the work was completed. This test is to confirm that the chemical has been adequately dispersed throughout the system and meets the required chemical levels. This testing is also done in conjunction with the PPDMC PM Manager or designee for agreement on the chemical level.

I. Should the test not meet the desired level, then additional chemicals should be added by the contractor and steps 7 through 9 repeated until the level is satisfactory.

3.2 PIPE CLEANING

A. General:
   1. Piping systems shall be cleaned before they are used for any purpose except pressure tests, which shall be conducted before cleaning. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer. Remove water filter elements from system before starting circulation.
   2. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
   3. Remove, clean, and replace strainer screens or filters.
   4. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.

5. New piping system shall not be connected to existing system for operation until flushing and cleaning have been completed. Obtain permission from Owner prior to opening up new work to existing system.

B. Water Systems:

1. Piping systems shall be filled, vented and circulated employing chemical cleaner solution for period of at least 24 hours or more in accordance with manufacturer's recommendations and job site chemical tests. Bring concentration to level, which raises M Alkalinity to manufacturer's recommended value above that for existing water used for fill. Conduct chemical tests to verify levels and submit results to Architect/Engineer. Flush detergent clear with continuous draining and make-up water fill for period of at least 12 hours or more until original M Alkalinity level is achieved (or until pH of system water is within 0.5 pH of make-up water). Conduct chemical tests to verify levels and submit results to Architect/Engineer. When cleaning process is complete, replace strainers or filters and reconnect permanent pumping apparatus.

C. Steam Systems:

1. Apply heat to produce steam for piping system and maintain for 8 hours minimum. Bypass traps and waste condensate. When cleaning process is complete, replace strainers and connect traps for service.

3.3 GLYCOL WATER TREATMENT

A. Provide 40% ethylene glycol treatment for all systems that have glycol.

B. Follow procedure outlined above.

C. Follow glycol manufacturer's recommendation for pipe cleaning, flushing and fill preparation and procedure.

D. Use premixed solution or use dilution water as required by manufacturer.

END OF SECTION

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SECTION 23-3114 DUCTWORK

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 REFERENCE

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

1.3 SUBMITTALS

A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards where applicable. Each duct system schedule shall include, but not be limited to, the following:

1. Name of Contractor/manufacturer fabricating each duct system.
2. Material and gauge.
3. Pressure class.
4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system.
5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures.
6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge.
7. Type of longitudinal seam.
8. Fitting construction details.
9. Support methods including spacing, upper attachments, and lower attachments.
10. Sealant and gasket.
11. Sealing class.

B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME requirements for testing meters.

C. 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 D9.1-90 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".

1.4 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. Unless otherwise indicated, construct ductwork to meet functional criteria defined in Chapter VII of SMACNA HVAC Duct Construction Standards, Metal and Flexible, 1995.

E. Unless otherwise indicated, pressure class for VAV system supply ductwork between supply fan discharge and air terminal device inlet shall be equal to static pressure at fan discharge but not less than 4" WG; pressure class for ductwork on suction side of air handling unit and suction side of return fan shall be equal to static pressure at inlet of return fan but not less than -2" WG.

F. Unless otherwise indicated, pressure class for fume hood exhaust ductwork between exhaust fan inlet and exhaust valve outlet shall be equal to static pressure at exhaust fan inlet but not less than -4" WG.

G. Unless otherwise indicated, pressure class for constant air volume system ductwork shall be equal to external static pressure (fan entrance or discharge pressure minus associated unit internal component pressure drop), but not less than + or - 2" WG.

H. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.

I. Except as modified in this Section of specifications, use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications:

1. HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition, 1995, for rectangular and round ductwork up to positive 10" WG and negative 10" WG and flat oval ductwork up to positive 10" WG.
   a. Internal tie rods or bracing are not allowed for duct 48" and smaller for high pressure ductwork. Tie rods shall be 1/2" or 3/4" galvanized steel conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod.

b. Internal tie rods are not allowed for ductwork in chase and other non-accessible spaces.

c. Midpanel tie rods described in SMACNA Addendum No. 1, November 1997, are not allowed.

2. Round Industrial Duct Construction Standards, 2nd Printing 1980.

3. Accepted Industry Practice for Industrial Duct Construction, 1st Edition, 4th Printing, 1988, for round ductwork -4" to -20" WG (Table 1-A) and for rectangular ductwork -4" to -20" WG (Table 2-A).

1.6 WELDING REQUIREMENTS

A. The following requirements cover arc and braze welding of nonstructural sheet metal ductwork for HVAC, architectural metal and other FDA process applications where pressures do not exceed 120" WG (positive or negative). These requirements also apply to welding of structural members whose sole purpose is stiffening, supporting, or reinforcing of sheet metal material, as well as attachment of brackets or other accessories/components required to provide complete systems.

B. Procedure and Qualification:

1. Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) shall be prepared by installing contractor and/or fabricator prior to execution of related work. Qualification of welding procedure shall meet or exceed requirements of the latest revision of American Welding Society, Sheet Metal Welding Code ANSI/AWS D9.1.

2. Provide certification of satisfactory performance testing for all welders and welding operators, which provide welding services on project.

3. Establish and provide written quality assurance/quality control (QA/QC) procedures to ensure compliance with specification requirements. Clearly identify appropriate steps for safe welding procedures (review Appendix J of D9.1) including additional safety material, screens, eye, personnel and clothing protection, fire suppression equipment, and fume extraction equipment needed adjacent to welding work area.

PART 2 PRODUCTS

2.1 GALVANIZED STEEL SHEET

A. First quality, lock former quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924 (formerly ASTM A525) or ASTM A653 (formerly ASTM A527). Galvanized coating shall be G90.

B. Use G 90 galvaneal or Zincgrip where painting is specified.

2.2 FLEXIBLE DUCT

A. Manufacturers: Casco or Flexmaster.

B. Factory fabricated, UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.

C. Flexible duct shall be suitable for:

1. Operating Temperature: -20 to 250°F

2. Operating Pressure: +10" WG (4-12" ID)

3. Velocity: 5000 fpm

D. Unless otherwise indicated, duct shall be metallic insulated type.

E. Insulation shall be minimum 1-1/2" fiberglass insulation blanket with maximum thermal conductance of 0.23 K at 75°F. Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with minimum perm rating of 0.05 perm.

F. Insulation material shall not be exposed to air stream.

G. Lined flexible duct shall have the following minimum acoustical performance in accordance with ARI Standard 885. Dynamic Insertion Loss in each octave band of 5 ft or 10 ft straight duct shall not be less than the following:

Dynamic Insertion Loss (dB)
Octave Band Center Frequency (Hz)
(Based on 5 ft length)

Duct Diameter (in.)	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

(Based on 10 ft length)

Duct Diameter (in.)	125	250	500	1000	2000	4000
6	10	15	28	33	35	22
8	10	18	29	32	32	20
10	9	19	28	31	29	18

2.3 MANUFACTURED ROUND OR FLAT OVAL DUCTWORK (Positive Pressure)

A. Single Wall:

1. Manufacturers: Ajax, Lindab, Semco or United McGill, equal to United McGill Uni-Seal duct and fittings suitable to positive 10" WG.

2. Ducts shall be machine formed round and/or flat oval as shown on drawings, constructed of galvanized steel meeting ASTM A-653. 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.

2.4 MANUFACTURED ROUND DUCTWORK (Negative Pressure)

A. Manufacturers: United McGill Industrial duct and fittings. Semco and Lindab are acceptable manufacturers, provided meeting requirements in this Section.

B. Ducts shall be machine formed round duct constructed of galvanized steel meeting ASTM A-653. 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. Round spiral duct gauge/reinforcement shall be as follows:

Duct Diameter (Inches)	0 to -10" WG Gauge/Reinforcement	-10 to -20" WG Gauge/Reinforcement
3 - 7	26 ga	26 ga
7-1/2 - 8	26 ga	26 ga
8-1/2 - 12	24 ga	24 ga
12-1/2 - 15	24 ga	22 ga
16 - 18	22 ga	20 ga
19 - 22	22 ga	18 ga
23 - 26	20 ga	18 ga
27 - 34	18 ga	18 ga w/AR 12 ft c/c or 16 ga
35 - 42	18 ga w/FL or 16 ga	18 ga w/FL + AR 6 ft c/c or 16 ga w/FL
44 - 50	18 ga w/FL + AR 6 ft c/c or 16 ga w/FL	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
52 - 60	18 ga w/FL + AR 6 ft c/c or 16 ga w/FL	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
62 - 72	16 ga w/FL + AR 6 ft c/c or 14 ga w/FL	16 ga w/FL + AR 6 ft c/c or 14 ga w/FL

AR = single angle ring reinforcement at maximum indicated ft on center spacing.

FL = fully welded flange angle rings as joint connections at maximum 12 ft spacing.

E. Fitting gauge shall be one even gauge heavier than the lightest allowable gauge of connecting downstream section of duct.

2.5 DUCT SEALANT AND GASKET

A. Sealant:

1. UL Classified sealant as compounded specifically for sealing joints and seams in ductwork. Hardcast, United McGill, Ductmate, Mon-Eco Industries or H.B. Fuller/Foster. Duct tapes are not allowed.
2. Select sealants as recommended by manufacturer for specific application.
3. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, detailed installation instructions.

B. Gaskets:

1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

C. Duct Sealant and Gaskets for Fume Hood Exhaust Ductwork:

1. Chemical resistant sealant similar to Hardcast.
2. Gasket material shall be Butyl based tape similar to Ductmate 440 Gasket Tape.
3. Gasket thickness and width shall be as required for flange and surface irregularities to seal joint air tight.

PART 3 EXECUTION

3.1 GENERAL

A. Install ductwork parallel to building walls and ceilings and at such heights not to obstruct any portion of ceiling, window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment. Install ductwork above accessible ceilings to maintain minimum 4" clearance between bottom of duct and top of ceiling. Install ductwork through shell spaces tight to structure to maintain clearance for fit-up equipment and systems. 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, ducts need not be enlarged if decrease in area does not exceed 10%. If decrease in area would exceed 10%, enlarge duct to maintain duct area not less than 90% of that shown on drawings. In all cases, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.

C. At 3rd/4th Floor mechanical room, closely coordinate and phase duct construction to allow installation of piping, fire protection, electrical, and other services. Duct installation shall allow for insulation and sealing of ductwork as specified above.

D. Ductwork shall be free of kinks and dents.

E. 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.

F. Provide transitions where different size or different shape ductwork segments are connected. Unless otherwise indicated, make diverging transitions with maximum angle of 15 degrees per side (30 degrees total diverging) and converging transitions with maximum angle of 25 degrees per side (50 degrees total converging).

G. Refer to ductwork symbols list on drawings for additional and dimensional requirements for fittings.

H. Seal duct seams and joints to meet SMACNA Class A as minimum for all ductwork including low-pressure ductwork.

I. Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to Part 1, Design Criteria for internal tie rods.

J. Support coils, filters, air terminals, dampers or other devices installed in duct systems with angles or channels, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.

K. Air terminal devices may be supported by strap hangers if air terminal manufacturer approves. Strap hangers are not allowed for fan powered devices, double wall type and Titus Steri-Loc type devices.

L. Install outside air intake duct to pitch down at 1" per 20 ft toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.

M. Blank off unused portion of outside air intake or exhaust louvers.

N. 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.

O. 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.

P. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.

Q. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:

1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.2 ELBOWS

A. Rectangular Duct:

1. Unless specific type is indicated, use radius elbows with minimum centerline radius to width or diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use the following elbows.
   a. Supply Air Ductwork:
      1) 1.0 radius elbows.
      2) Square throat elbows with turning vanes where 1.0 radius elbows do not fit.
   b. Return or Exhaust Air Ductwork:
      1) 1.0 radius elbows with full splitter vanes as follows:
         a) One vane for duct width 24” to 48”.
         b) Two vanes for duct width 49” to 72”.
         c) Three vanes for duct width 73” and larger.
         d) Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standard, pages A41 through A43.
      2) 45 degree mitered throat with radius heel elbows with full splitter vanes as follows where 1.0 radius elbows do not fit:
         a) One vane for duct width 12” to 24”.
         b) Two vanes for duct width 25” to 36”.
         c) Three vanes for duct width 36” and larger.
         d) Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standards, pages A41 through A43.

3) Square throat - radius heel elbows or square throat elbows with turning vanes are not allowed unless specifically indicated.

B. Round and Oval Duct:

1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.

3.3 LONGITUDINAL SEAM

A. Rectangular Duct:

1. Unless otherwise indicated, use Pittsburgh lock seam for rectangular ductwork except button punch snap lock may be used for ductwork downstream of supply air terminal devices.

2. Button punch snap lock construction is not allowed on aluminum ductwork.

B. Round and Oval Duct:

1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards. Snaplock seams are not allowed.

3.4 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, Second Edition, 1995, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2 x 1-1/2 x 1/4 angle at each side of transverse joint.

4. Refer to Detail for non-externally insulated outdoor ductwork.

B. Round and Flat Oval 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) 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 "self-sealing" duct system will be acceptable for supply air ductwork.

3.5 DUCT SUPPORTS

A. Unless otherwise indicated, use trapeze hangers with rods or angles to support the following rectangular ductwork:

1. Non-insulated ductwork 48" and wider.

2. Externally insulated ductwork.

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 over 24" diameter, use 2 hanger rods with half round trapeze. Trapeze shall be in accordance with the following schedule:

Duct Size	Trapeze (Half Round)
25" through 36"	2" x 10 gauge
37" through 48"	1-1/2" x 1-1/2" x 1/4"
49" through 60"	2" x 2" x 1/4"
61" through 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 ducts located on roof as detailed.

F. Support vertical ducts at every floor, but not exceeding 12 ft.

G. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:

1. Hook or loop
2. Nailed pin fasteners
3. Expansion nails without washers.
4. Powder charged or mechanically driven fasteners (forced entry anchors).
5. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps)
6. Friction clamps for ductwork over 12"
7. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 4-3 of SMACNA HVAC Duct Construction Standards 95).
8. Wire hanger.
9. Trapeze hangers supported by wires or straps.
10. Rods, straps or welded studs directly attached to metal deck
11. Drilled hole with attachment to structural steel
12. Self tapping screws into straps
13. Lag screw expansion anchor.
14. Rivets

H. Supporting devices shall be standard products of manufacturers having published load ratings.

I. Refer to Section 20 0529 - Mechanical Supporting Devices for additional support requirements including attachments to structures.

J. For welded ducts, soldered ducts or ducts with water tight joints, do not use supports utilizing screws or other penetrations into ductwork.

K. Unless architectural documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the project structural engineer for location and size of opening prior to execution of work.

3.6 SHEET METAL WELDING

A. All welded ductwork shall be butt-welded. Backing material and slip joints are not allowed.

B. Attach welding cable leads directly to base metal to be welded. Do not jumper welding cable leads through building structure, to avoid emission of stray voltage/current through building structure.

C. Welds on exposed ductwork in occupied spaces shall be brush polished with stainless steel brush.

D. Welds at exterior of building shall be ground smooth and brush polished with stainless steel brush to prevent atmospheric contamination and rust formation.

3.7 PROTECTION OF DUCTWORK

A. Protect ductwork during construction against entry of foreign matter and construction dirt.

B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.

C. Remove dirt and foreign matter from entire duct system and clean diffusers, registers and grilles before operating fans.

3.8 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 all ductwork unless otherwise indicated in this Section.

D. Leakage test shall be in accordance with test method described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section.

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. Coordinate leakage test requirements with duct installation and phasing requirements at 3rd/4th Floor Mechanical Room. Duct construction and leakage tests shall be coordinated and phased to achieve specified leakage rates without requiring removal of services installed below tested system.

I. Leakage rate shall not exceed more than 2% of system design air quantity for low-pressure ductwork, determined in accordance with Appendix C of SMACNA HVAC Air Duct Leakage Test Manual.

J. Leakage rate shall not exceed more than 1% of system design air quantity for high-pressure ductwork, determined in accordance with Appendix C of SMACNA HVAC Air Duct Leakage Test Manual.

K. Welded ductwork shall be air and watertight and shall have no air leakage.

L. Leakage Test for Ductwork Downstream of Air Terminal Devices:

1. Representative samples of ductwork (approximately 10% of total linear feet of ductwork) shall require leakage test.

2. Engineer will decide samples of ductwork to be tested and date of leakage test to be conducted.

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 samples of ductwork as described above.

3.9 LOW PRESSURE DUCT CONSTRUCTION (Pressure Class 2" 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 degree entry fittings. For supply air ducts, expanded or conical taps may be used.

2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.

C. Do not use splitter dampers and/or extractors unless manual volume dampers alone do not accomplish the intended balancing. Obtain Engineer's written approval before installing them. Use of splitter dampers and/or extractors will not eliminate need for specified or indicated manual volume dampers.

3.10 HIGH PRESSURE DUCT CONSTRUCTION (Pressure Class 3" and over)

A. Use manufactured ductwork.

B. Contractor fabricated ductwork meeting specified construction standards is acceptable with prior approval of Engineer.

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 expanded or conical tees for branch take-offs from mains.

F. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.

G. Provide positive pressure relief doors as indicated on drawings.

H. Provide negative pressure relief doors as indicated on drawings.

I. Construct high pressure ductwork for WG pressure class indicated in the following section.

3.11 AIR HANDLING UNIT SYSTEM DUCTWORK PRESSURE CLASS

A. Supply Air System

1. System consists of all supply air ductwork served by all Air Handling Units EXCEPT AHU's with external static pressure less than 2.0" W.G., where low pressure duct construction shall be used.
2. Construct duct for the pressure classes indicated below:

a.	From AO to louver to AHU OA damper	-2" WG
b.	From AHU to riser	+6" WG
c.	Riser	+6" WG
d.	Horizontal mains and branch mains	+4" WG
e.	From main or branch main to air terminal or control damper	+3" WG
f.	From air terminal or control damper to diffuser or grille	+2" WG

B. Return and Exhaust Air Systems

1. Systems consist of all ductwork served by all return/exhaust fans.
2. Construct duct for the pressure classes indicated below:

a.	From return/exhaust grille to air terminal	-2" WG
b.	From return/exhaust air terminal to horizontal main or branch main	-3” WG
c.	Horizontal main or branch main	-4" WG
d.	Risers	-6" WG
e.	From riser to fan	-6" WG
f.	From return fan to return air control damper	+3" WG
g.	From return air control damper to AHU	+3" WG
h.	From return fan to outside air intake and relieve from return fan to relief air louver	+2" WG

3.12 DRYER EXHAUST VENT

A. Dryer exhaust ductwork shall be constructed of aluminum.

1. Connections shall be angle ring or flange type.
2. Supports shall be strap type.
3. No screws into the ductwork will be allowed.

B. Construction to meet all low pressure round duct construction standards as specified above.

3.13 FLEXIBLE DUCT

A. Install flexible duct as specified below.

B. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of specifications.

C. In supply air systems with air terminal devices, flexible ducts shall be used for duct connections to diffusers, grilles, and registers for sound attenuation purposes, except above non-accessible ceilings. Flexible ducts shall be minimum 3 ft long and maximum 4 ft long.

D. 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 4 ft in length, unless noted otherwise.

E. Flexible ducts are not allowed for special exhaust systems, such dryer exhaust.

F. Centerline radius of bends shall not be less than 1-1/2 duct diameters.

G. Support flexible ductwork at connection to diffuser/grille with Flexright flexible duct elbow support or similar, and a maximum of 3 ft on center, with no portion lying on ceiling supporting system and a minimum of one hanger on each run over 4 ft in length.

H. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.

I. Connect flexible duct liner to collars with nylon adjustable, self-locking, strap and a minimum of 3 sheet metal screws. If collars have beads, position draw bands behind beads.

J. Pull insulation and vapor barrier jacket over liner connection and secure with strap. Flexible duct shall be sealed air tight at each connection with self-adhesive aluminum tape.

K. Flexible ducts are not allowed above non-accessible ceilings.

L. Flexible ducts are not allowed in high pressure ductwork.

M. Flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

N. Total offset in any run of flexible duct shall not exceed 180 degrees.

3.14 DUCT CLEANING

A. Clean all new duct systems prior to testing, adjusting, and balancing. Mark positions of dampers and directional air mechanical devices before cleaning.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with division 23 3314 Ductwork Specialties for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Vent vacuuming system to outdoors and use filter to collect debris removed from HVAC system. Locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers)
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air handling unit internal surfaces and components including mixing box, coil section, condensate drain pans, humidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Supply and return air ducts, dampers, actuators, and turning vanes.
6. Dedicated exhaust and ventilation components.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contamination from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Visually inspect all metal ducts for debris and contaminants. Re-clean and re-inspect as necessary when debris or contaminants are discovered.

END OF SECTION

SECTION 23 3314 DUCTWORK SPECIALTIES

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 and Smoke Dampers)

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. 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

1.4 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.

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".

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.

I. Where ceiling fire dampers are used, they shall be similar to Ruskin CFD(R) 2 or 3, UL Classified for installation in fire rated floor or roof/ceiling assemblies.

2.5 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Ruskin, Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff, Louvers and Dampers similar to Ruskin FSD-60

B. Dampers shall meet requirements of NFPA 90A. Dampers shall be 1-1/2 or 3 h rated as shown on drawings, leakage rated at no higher than leakage Class I (4 cfm/ft^2 at 1" WG and 8 cfm/ft^2 at 4" WG) under UL 555/555S at temperature category 350°F, and compatible with system static pressures. Furnish dampers with factory-mounted, caulked sleeves and damper operators.

C. Dampers shall use airfoil shaped damper blades. Dampers shall be rated for minimum 4” WG static pressure and 2000 fpm air velocity.

D. For round ducts, dampers equal to Ruskin Model FSDR 25 may be used.

E. Operators shall be 120 V electric powered with auxiliary switch built in for position indication, factory installed outside airstream, linked to dampers for fail closed operation, and be UL Listed and labeled for the application. Operators to be capable of closing damper at pressures encountered in system.

F. Dampers shall be furnished with heat sensor set at 165°F.

G. Furnish damper test switch similar to Ruskin Model DTS.

H. Smoke detector required at each damper will be provided by Electrical Contractor.

I. Firestat

1. Dampers shall be furnished with UL Classified firestat equal to Ruskin TS150-EZ, functioning to close dampers when duct temperatures exceed 165°F while allowing reset capability from control system specified in Section 23 0923. Include damper position switch linked directly to damper blade to provide capability of remotely indicating damper blade position. Firestat and position indicator switches to be capable of interfacing electrically with building fire alarm system or automation system.
2. Firestats shall be equipped with high limit temperature sensors meeting requirements of NFPA 92A by returning damper to fire protection mode when temperature reaches 350°F.
3. Firestats and position switches shall be **[XXX]** V.

J. Furnish EP switches where pneumatic operators are used.

K. Submit UL installation details showing mounting method and duct connection method.

2.6 SMOKE DAMPERS

A. Manufacturers: Air Balance, Johnson Controls, Ruskin, Greenheck, Nailor, NCA Manufacturing, Cesco, Pottorff, Louvers and Dampers or Prefco, similar to Ruskin SD-60.

B. Dampers shall be leakage rated at no higher than Leakage Class I (4 cfm/ft^2 at 1" WG and 8 cfm/ft^2 at 4" WG) under UL 555S at temperature category 250°F. Furnish dampers with factory-mounted, caulked sleeve and actuator assemblies. Damper shall have 16 ga or heavier frame with air foil-shaped blades, rated to minimum 4" WG in closed position and to 2000 fpm in open position.

C. For round ducts, dampers equal to Ruskin Model SDRS 25 may be used.

D. Actuator assemblies shall be installed outside airstream, linked to damper for fail (normally) closed operation. Actuator shall be capable of closing damper at pressures encountered in system.

E. Size smoke dampers as close as possible to duct size, but in no case is damper size to be less than duct size.

F. Actuators shall be 120 V electric powered with auxiliary switch built in for position indication.

G. Furnish damper test switch similar to Ruskin Model DTS.

H. Smoke detector required at each damper will be provided by Electrical Contractor.

2.7 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 non-hinged type with cam latches.
   2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.
   3. Sandwich style access doors made by Ductmate, Ward Industries, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.

C. High Pressure Ducts (Pressure Class 3" and Over):
   1. Doors shall be non-hinged type with cam latches.
   2. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10" WG.
   3. Sandwich access doors made by Ductmate, Ward Industries, Pottorf, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.

2.8 FLASHINGS

A. Construct counterflashings of 16 ga galvanized Armco Zinc-Grip. Flashings are by General Contractor unless otherwise indicated.

2.9 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 indoor 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 outdoor use 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.

C. Special Exhaust Ductwork:

1. Material for indoor use shall be 17 oz per square yard, teflon or silicon coated, tensile strength of 200 lbs x 250 lbs, tear strength of 50 lbs x 40 lbs, suitable for -65°F to 500°F, similar to Duro Dyne Thermafab.
2. Material for outdoor use shall be combination of inner layer of Duro Dyne Thermafab and outer layer of Durolon.

2.10 SOUND ATTENUATING DEVICES

A. Manufacturers: Semco, United McGill, Aeroacoustic, Vibro-Acoustics, VAW Systems, Price, or Ruskin

B. Units shall be tested in accordance with ASTM E-477-99 silencer test standard in aero-acoustic test facility which is NVLAP accredited for ASTM E-477-99 Standard. Each test shall have been conducted within last 12-month period. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance.

C. Outer casing of units shall be not less than 22 ga G90 galvanized steel in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork for 8" WG or pressure class indicated for duct system, if it is higher than 8" WG. Seams shall be lock formed or continuously welded and mastic filled.

D. Acoustic Materials:

1. Media shall be long fiber fiberglass protected with covering material and lined with not less than 26 ga galvanized perforated steel. Filler and facing material shall meet requirements of NFPA 90A with flame spread rating of 25 or less, and smoke development rating of 50 or less.

E. Covering Materials:

1. Covering material shall be Mylar film.
2. Provide spacers between covering material and perforated metal.

F. Ends of attenuators shall be covered at factory with plastic, heavy-duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuators. Caps shall not be removed until attenuator is installed in duct system.

G. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.

2.11 BIRD AND INSECT SCREENS

A. Bird screens shall be 1/2" square mesh formed with 0.063" diameter aluminum wire. Insect screen to be 18 x 16 with 0.017" diameter aluminum mesh.

B. Frame shall be removable type of minimum 12 ga, extruded aluminum.

2.12 AIR MIXING DEVICES

A. Manufacturers: Blender Products, Inc

B. Units shall be not less than 0.08" aluminum of all welded construction.

C. Units shall be completely fixed devices capable of providing mixed air temperatures within 6°F of theoretical values.

2.13 AIR FLOW MEASURING UNITS

A. Furnished by Control Contractor.

2.14 REMOTE OPERATED VOLUME CONTROL DAMPERS

A. Young Regulator Co. or Metropolitan Air Technology similar to Young Regulator Model 830 dampers, furnished with Bowden 270 Series remote cable controls.

2.15 PRESSURE RELIEF DOORS

A. Similar to Ruskin Model PRD 18, Kees Model BO, or Pottorff Model PPR-B0 for positive pressure and Ruskin Model NRD 18, Kees Model BI, or Pottorff Model NPR-BI for negative pressure applications.

B. Doors and frames shall be 12 ga galvanized steel with seal around door perimeter. Use galvanized steel or stainless steel to match ductwork material. Doors shall be double-wall, insulated, when installed in insulated ductwork.

C. Doors shall open automatically to relieve excess pressure above set point and to close when pressure is reduced to less than 3" WG. Setting shall be adjustable from 3" to 8" WG with 1" WG increments in between.

2.16 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.

2.17 CONTROL DAMPERS

A. Furnished by Control Contractor.

2.18 SMOKE DAMPERS

A. Furnished by Control Contractor.

2.19 BIPOLAR IONIZATION

A. Similar to GPS iMOD

B. Units shall meet UL 2998 standards for ozone production.

C. Provide duct mounted ion detector for monitoring of ion production via the BAS.

PART 3 - EXECUTION

3.1 MANUAL BALANCING DAMPERS

A. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.

B. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.

C. Do not install balancing dampers in supply ductwork upstream of air terminal devices.

D. Balancing damper shall not be used 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 AND COMBINATION FIRE/SMOKE 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, heating and cooling coils, reheat coils, humidifiers, filters, bird/insect screens, valves and control devices within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.

B. Locate access doors for greatest ease of access.

C. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

Rectangular Duct Size	Minimum Access Door Quantity and Size
10”and smaller	(1) 8” x 8”
12” to 15” and smaller	(1) 10” x 10”
16” to 21”	(1) 14” x 14”
22” 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
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.

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.

B. Duct flexible connections are not allowed for fan connection serving kitchen hood, or perchloric acid hood.

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 BIRD AND INSECT SCREENS

A. Provide bird screens or insect screens as indicated on drawings at louvers and at intake/exhaust openings.

B. Unless otherwise indicated, provide bird screens where filters are specified and insect screens where filters are not specified.

3.10 AIR MIXING DEVICES

A. Install air mixing devices as indicated on the drawings and/or as scheduled. Install devices and associated duct connection in strict accordance with manufacturer's recommendations.

3.11 AIR FLOW MEASURING UNITS

A. Install where indicated on the drawings and/or as scheduled and in accordance with manufacturer's recommendations.

3.12 REMOTE OPERATED VOLUME CONTROL DAMPERS

A. Install remote operated volume control dampers and remote operators as indicated on drawings.

B. Install connecting wire in the wall.

3.13 PRESSURE RELIEF DOORS

A. Install doors vertically where shown on drawings and in accordance with manufacturer's recommendations.

3.14 CONTROL DAMPERS

A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.

B. Install blank-off plates or transitions as specified in Control Sections.

C. Provide adequate operating clearance and access to operators.

D. For dampers located outdoor, provide weather protection enclosure for parts of damper such as linkage and actuator located outside of duct. Enclosure shall be removable and made of galvanized steel sheet.

3.15 SMOKE DAMPERS AND DETECTORS

A. Install smoke dampers in locations indicated on drawings. Allow room for operator installation and access to operator. Install access door in ductwork for access to damper. When damper is installed in location other than in smoke or fire rated wall, use SMACNA seal class A for ductwork between smoke damper and smoke rated wall for affected zone.

B. Smoke detectors will be provided by Electrical Contractor in locations indicated on drawings. Install access door in ductwork for access to detector sampling device.

3.16 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.

3.17 BIPOLAR IONIZATION

A. Duct mounted ionization located in ductwork shall be mounted on Unistrut inside the ductwork.

B. Provide lengths required for maximum airflow of the duct.

C. Mount ion detector downstream of ionization unit.

D. All electrical connections shall be hardwired outside of the duct. Seal all duct penetrations airtight.

E. Provide duct access door for access to the ionization modules for cleaning.

END OF SECTION

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SECTION 23-3400 FANS

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 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning 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. Fan curves
   5. Materials of construction
   6. Sound power levels
   7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives
   8. Wheel type, diameter, rpm, tip speed
   9. Required fan horsepower including drive losses
   10. Motor data (refer to Section 20 0513 - Motors)
   11. Vibration isolators furnished with fans
   12. Dimensions and weights
   13. Special coatings where applicable
   14. Color selection charts where applicable
   15. Manufacturer's installation instructions
   16. All other appropriate data

B. Fan curves shall include series of curves indicating relationship of flow rate (cfm) to static or total pressure for various fan speeds, brake horsepower curves, and selection range (surge curves, maximum rpm, etc).

C. Indicate performance data, based on both design air quantity and 110% of design air quantity.

D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and horsepower.

1.4 DESIGN CRITERIA

A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.

B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified. Motors for V-belt drives shall be furnished with adjustable rails or bases.

C. Each fan wheel shall be statically and dynamically balanced to grade G6.3 per ANSI S2.19. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-96 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.

D. For fans furnished with 5 HP or larger HP motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan, scheduled rpm shall not exceed the following values when fan is rigidly mounted.

1. Belt Drive (except Vane Axial) 0.15 in/sec peak velocity
2. Belt Drive Vane Axial 0.08 in/sec peak velocity
3. Direct Drive 0.08 in/sec peak velocity
4. Written records of run test and vibration test shall be available upon request.

E. Furnish fans specified with V-belt drives with either variable-pitch or fixed-pitch sheaves for drives 3 HP and smaller and fixed-pitch sheaves for drives 5 HP and larger. Select variable pitch sheaves to drive fan at such speed as to produce specified capacity at approximate midpoint of sheave adjustment.

F. When fixed-pitch sheaves are furnished, system air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.

G. 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.

H. Unless otherwise indicated, V-belt drives shall be selected for 150% of motor nameplate horsepower.

I. Provide OSHA compliant belt and shaft guards for belt driven fans. Provide speed test openings at shaft locations. Paint guards bright yellow. Belt driven fans on smoke exhaust systems shall be provided with 1.5 time required number of belts (2 minimum).

J. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.

K. 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.

L. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.

M. 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.

N. Exhaust fans serving fume hoods shall be marked with arrows to indicate proper direction of rotation.

O. Unless otherwise scheduled, AMCA Type A spark resistant construction shall be used for fans handling flammable or grease laden, vapors.

P. Fans scheduled with baked phenolic coating shall have internal parts in contact with air stream sand blasted to white metal finish and coated within 24 hours. Coating thickness shall be 5 mils minimum, equal to Heresite P-4403 (first 3 coats) and L-66L (final 2 coats) with each coat baked separately. Dry film thickness must be verified before final baking. Paint all exterior metal parts with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

PART 2 PRODUCTS

2.1 CENTRIFUGAL FANS (GENERAL EXHAUST FANS)

A. Manufacturers: Greenheck, Barry, Peerless, Buffalo, Chicago Blower, New York Blower, Trane, Twin City or Cook.

B. Housings: Heavy gauge steel, continuously welded throughout, braced and supported by structural channels or angle irons to prevent vibration or pulsation, flanged outlet, fully streamlined inlet.

C. Wheels: The fan wheel shall be of the non-overloading backward inclined centrifugal type. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.

D. Bearings: Air handling quality, heavy duty, grease lubricated, ball or roller, self-aligning, pillow block type. Bearings shall be selected for minimum life (ABMA L-10) of not less than 40,000 hrs operation at maximum cataloged operating speed based on ABMA 9 and 11. Furnish bearings with pressure relief type external grease fittings.

E. Painting: All metal parts shall be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

F. Mounting Rails: Furnish common mounting rails for fan and motor as appropriate for fan arrangement indicated.

G. Dampers: Provide gravity backdraft dampers, for fans not provided with motorized dampers, for mounting at fan inlet. Backdraft dampers shall be similar to Ruskin Model CBS 92, having aluminum airfoil-shaped blades, ball bearings and be rated to 4000 fpm. Dampers shall have blade and jamb seals with leakage rating no higher than 13.5 cfm/ft^2 for damper width 36" and larger based on pressure differential of 1" WG.

H. Inlet Screens: Minimum 16 gauge galvanized, 1" wire mesh for fans without inlet ductwork.

I. Access Doors: Bolted and gasketed type in fan housing for inspection of interiors and wheel.

J. Provide NEMA 4 rated disconnect switch.

2.2 PLENUM FANS

A. Manufacturers: Greenheck, Barry, Chicago Blower, Twin City, or Cook.

B. General: Fans shall be airfoil centrifugal type designed for industrial duty and suitable for continuous operation. Fans shall be single width, single inlet, arrangement 3, plenum fans with capacities and operating characteristics as indicated on schedules.

C. Hubs: Hubs shall be cast or welded fabricated hubs with straight bores and keyways. Hubs shall be screwed to the shaft with a minimum of 2 set screws for positive attachment. Hubs using taper lock bushings are not acceptable.

D. Wheels: Airfoil type, double skinned and welded to center and wheel sideplates. Fan impeller diameters shall conform to AMCA Standard 99-2401-82. Fan blades shall be designed to provide smooth airflow over all surfaces of blade. Fan shafts shall be solid AISI 1040 or 1045 steel. Straight shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shaft shall be sized to run at a minimum of 20% greater than the maximum AMCA class speed.

E. Bearings: Air handling quality, heavy-duty, grease lubricated, pillow block, self-aligning ball or roller type. Bearings shall be selected for minimum life (ABMA L10) of not less than 80,000 hr operation at maximum cataloged operating speed.

F. Screen Enclosure: Entire plug fan and drive assembly shall be encased with protective screen enclosure. Enclosure shall be constructed of aluminum or galvanized steel mesh or expanded metal and sized to have no measurable system effect on fan performance. Screen shall be reinforced as required to maintain stable structure during fan operation. Access shall be provided for periodic service. Door shall be of suitable size to allow service personnel into enclosure. Enclosure shall be designed and constructed to allow for complete disassembly.

G. Inlet Screens: Heavy gauge, corrosion resistant, zinc plated steel wire for fans without inlet ductwork.

H. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to insure full loading of blades. Inlet cones shall be heavy gauge steel.

I. Painting: All metal parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

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. Trade Contractor will install fans on existing room curbs per manufacturer's installation instructions and details.

C. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.

3.2 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

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 _____

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SECTION 23-3600 AIR TERMINAL DEVICES

PART 1 GENERAL

1.1 RELATED WORK

A. Section 23-0901 - Control Systems Integration

B. Section 23-0993 - Control Sequences

C. Section 23-3114 - Ductwork (Support)

D. Section 23-3314 - Ductwork Specialties (Access Doors)

E. Section 23-8214 - Heating and Cooling Terminal Devices

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning 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. Sound rating data
   6. Dimensions
   7. All other appropriate data

1.4 DESIGN CRITERIA

A. Where any of air terminal devices are indicated on drawings to control space conditions in conjunction with reheat coil, that reheat coil may be furnished as integral part of or standard accessory to devices specified below. See related work above.

B. When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.

C. Unless otherwise stated, units shall be system pressure independent and maintain air volume within ± 5% of required airflow regardless of system air pressure. Inlet velocity pressure sensor shall be multi-point center averaging type and be capable of amplifying pressure signals.

D. Unless otherwise stated, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 22 gauge.

E. Joints and seams of air terminal devices shall be sealed with appropriate sealant to minimize casing air leakage. Seal joints and seams not factory sealed in field as specified in Part 3.

F. Unit performance shall be certified in accordance with ARI Standard 880 including sound rating data certified for both casing discharge and radiated sound levels from 125 through 4000 Hz.

G. Supply air units shall be capable of operating from minimum inlet static pressure scheduled to 3" WG.

H. Provide supply air units with internal thermal insulation faced with minimum 0.001" thick aluminum foil. Insulation shall be compressed glass fiber with minimum R-value of 3.5. Insulation and facing shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), and NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance). Seal all insulation edgest exposed to the airstream. Liner assembly shall be similar to Price FB.

I. Sound attenuators, where specified or required to meet sound performance specified for air terminal devices, shall be constructed of all metal or sound attenuating fiber material with erosion protection liner as required to meet sound requirement specified. Refer to Section 23 3314 - Ductwork Specialties for sound attenuators and erosion protection.

J. Unit manufacturer or manufacturer's designated representative will be required to verify air terminal device performance and adjust or replace device within warranty period when it is determined that problem exists in area served by device.

K. Room sound levels due to discharge and/or casing radiation from units when operating from minimum pressure scheduled to 2" WG inlet static pressure shall not exceed noise criteria (NC) values in any spaces as indicated below. If units exceed sound level specified, provide terminal sound attenuators to comply with the noise criteria stated below. Refer to Section 23 3314 - Ductwork Specialties for sound attenuating devices.

Type of Room	Noise Criteria (NC)
All spaces unless otherwise indicated	35
Private Office/Reception	30
Open Office	40
Laboratories and Support Spaces	40
Restrooms/Locker Rooms	45
Patient Rooms	30
Operating Rooms	35
Waiting Rooms	40
Conference Rooms	30
Auditorium	25

1.5 CONTROLS COORDINATION

A. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by unit manufacturer for unit manufacturer's factory mounting. Unit manufacturer and Control Contractor shall coordinate for proper factory installation.

B. Unit manufacturer shall perform preliminary calibration based on scheduled airflow rates.

C. Control Contractor shall be responsible for calibrating actuators and controllers through TAB work for scheduled airflow rates.

PART 2 PRODUCTS

2.1 VARIABLE VOLUME AIR TERMINAL DEVICES

A. Manufacturers: Phoenix, E. H. Price, Krueger, Enviro-Tec, Nailor, Tuttle and Bailey, Trane or Carrier.

B. Units shall be suitable for 24 volt electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.

C. Units shall be capable of modulating to full closed position with maximum leakage of 1%.

D. Furnish units with reheat coils having capacities as indicated in schedules.

E. Provide access doors for all boxes with reheat coils at inlet side of coils. Reheat coils shall be shipped loose and field mounted. Provide sheet metal connecting section between units and reheat coils for mounting access doors. Refer to Section 23 3314 - Ductwork Specialties for access doors.

2.2 RETURN OR EXHAUST AIR TERMINAL DEVICES (VALVES)

A. Units shall be suitable for 24 volt electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit. Units shall be similar to Price Model SDV.

B. Units shall be capable of modulating to full closed position with maximum leakage of 1%.

C. Unit casing shall be minimum 22 gauge galvanized steel unless otherwise specified.

D. Casing leakage shall not exceed 3 cfm for inlet sizes 8 and smaller and 5 cfm for inlet sizes 9 and larger at 1.5" WG differential static pressure.

E. Damper shall be heavy gauge steel. Shaft shall be steel with bronze iolite self-lubricating bearings. Damper shall incorporate mechanical stop to prevent overstroking and synthetic seal to limit close-off leakage to 4 cfm at 1.5" WG differential pressure.

F. Unit casing, damper and shaft for fume hood and BSC exhaust shall be stainless steel.

G. Unit shall incorporate multi-point, center averaging velocity sensor. Sensor shall provide signal measurable by controller at inlet velocities of 500 fpm. Sensor shall provide control signal accuracy of ±5%, with the same size inlet duct at any inlet condition. Sensor shall be removable without additional access doors, similar to Price SP300.

2.3 VENTURI TYPE AIR TERMINAL DEVICES

A. Manufacturers: Phoenix Controls or approved equal.

B. Units shall be linearized venturi type pressure independent and capable of modulating to fully closed position.

C. Supply Air and General Exhaust Air Valves:

1. Unit housings and cones shall be uncoated aluminum construction. Shaft and all hardware exposed to airstream to be 316L stainless steel.

D. Exhaust Air Valves:

1. Unit housings and cones shall be uncoated aluminum construction. Shaft and all hardware exposed to airstream to be 316L stainless steel.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings and according to manufacturer's instructions.

B. Install units with sufficient service space to unit control, actuators and access panels.

C. Seal joints and seams of units not factory sealed to meet allowable leakage rate specified for low pressure ductwork.

D. Connect terminal devices to ductwork with removable type joints.

E. Provide minimum length of 3 times box inlet diameter of straight rigid duct at box inlet.

F. Provide access doors for terminal devices with reheat coils at inlet side of coils.

G. Provide access panels compatible with ceiling for all units located above non-accessible ceilings.

H. If Venturi type air terminal devices are used for supply air application, provide external insulation in accordance with Section 20-0700 - Mechanical System Insulation.

3.2 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 23-3614 PRESSURE RELATIONSHIP TEMPERATURE AND AIRFLOW CONTROL SYSTEM

PART 1 GENERAL

1.1 RELATED WORK

A. Division 01 - Submittal Procedures

B. Section 23 0595 - Air Systems Balance

C. Section 23 0901 - Control Systems Integration

D. Section 23 0902 - Control Valves and Dampers

E. Section 23 0903 - Control Instrumentation

F. Section 23 0993 - Control Sequences

G. Section 23 3314 - Ductwork Specialties (Sound attenuators and access doors)

H. Section 23 8214 - Heating and Cooling Terminal Devices

1.2 REFERENCE

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

1.3 DESCRIPTION

A. The airflow control system shall be furnished and installed to control the airflow into and out of patient rooms, operating rooms, and any room requiring a positive/negative pressure relationship to adjacent spaces in healthcare facilities. The airflow control system shall vary the amount of make-up/supply air into the room to operate the spaces at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain room pressurization in relation to adjacent spaces (positive or negative). The airflow control system shall be capable of operating as a standalone system or as a system integrated with the Building Management System (BMS).

1.4 SUBMITTALS

A. Refer to Division 01 - Submittal Procedures.

B. Submit shop drawings for all supply, and exhaust air terminals, actuators, controllers, master controllers, control wiring, pneumatic tubing, space temperature/humidity sensors and all accessories. Shop drawings shall be complete in all respects and shall include, but not be limited to the following:

1. Manufacturer's printed product data sheets indicating name and model number of all pieces of equipment.
2. Name, address and phone number of supplier.
3. Name, address and phone number of local representative.
4. Identification as referenced in documents.
5. Capacity/ratings and dimensional data.
6. Materials of construction and installation requirements.

C. Bill of material identifying actual product model number used for each control device for each schematic drawing.

D. Control drawings with graphic representation of system components. Identify controlled devices as referenced on plans with unique valve and damper tag numbers.

E. Electrical characteristics indicating any field wiring which is to be performed by others, type of signal wiring, and installation methods including raceway type and grounding method.

F. Supply and exhaust air terminal certified sound data for both casing discharge and radiated sound levels from 125 through 8000 Hz as tested in accordance with ASHRAE/ANSI Standard 130, S12.12 or ARI Standard 880.

G. Instrument specifications.

H. Controller description.

I. System/network architecture configuration diagram showing all controller / control panel types and locations and interconnecting wiring and interface points.

J. Written control sequences describing method of control, alarms, setpoints referenced to tag number of device.

K. Outline drawing showing overall dimension, component location and spacing, and interfacing connections sizes and locations.

L. Identify setpoint or adjustable control range for each control device.

M. Submit Completion Check List as specified in Section 23 0901 - Control Systems Integration.

N. Shop drawings and complete equipment and software descriptions shall be submitted in sufficient detail to assess equipment's conformance to this specification and physical size of equipment.

O. Organize submittal with table of contents and tabs for each section arranged by logical groups of devices.

1.5 DESIGN CRITERIA

A. Unit manufacturer, or his designated representative, will be required to verify air terminal device performance and adjust or replace device(s) within warranty period when it is determined that problem exists in area served by device(s).

B. Actuators and linkages shall be furnished and factory installed by Pressure Relationship, Temperature and Airflow Control Manufacturer (PRTACS).

C. Standard actuator of manufacturer is acceptable provided it meets criteria specified herein.

D. Actuator and its controller shall be calibrated and either factory set or field set through TAB work for scheduled airflow rates. Air terminals shall be capable of field calibration and readjustment with external gauge taps.

E. Refer to Air Terminal Device schedules for definition of minimum inlet static pressure requirement for each air terminal device as well as sizing criteria.

F. Provide all components not specifically indicated or specified, but necessary to make system function within intent of specification and in accordance with control sequences specified in Section 23 0993 - Control Sequences.

G. Size all control apparatus including all air terminals to provide stable control of systems and equipment served throughout specified operating range.

H. Any devices subject to corrosion, such as in fume hood exhaust ducts, shall be provided with appropriate corrosion protection.

1.6 CODES AND STANDARDS

A. All materials and workmanship described herein shall be in accordance with latest addition and addenda of codes and standards listed below:

1. AMCA Air Movement and Control Association
2. ARI American Refrigeration Institute
3. ASTM American Standards Testing and Materials
4. NEC National Electrical Code
5. NEMA National Electrical Manufacturers Association
6. NFPA National Fire Protection Association
7. UL Underwriters Laboratories

B. All work shall also comply with latest edition of North Carolina State Building Code.

1.7 FCC COMPLIANCE

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

1.8 ADJUSTMENT, PERFORMANCE TEST AND CERTIFICATION

A. After completion of installation, regulate and adjust all equipment provided in this contract as outlined in Completion Check List.

B. Conduct complete performance test for all systems to assure compliance with contract documents. Any components on systems found defective or not performing satisfactorily shall be readjusted and retested after necessary corrective measures are performed. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program.

C. Provide written certification signed by applicable person(s) for incorporation in O&M manuals stating date when successful completion of performance tests is achieved. Letter shall verify all controls are installed and software programs have been completely exercised for proper equipment operation.

1.9 GUARANTEE

A. Guarantee all work, materials, equipment, and controls against defects in workmanship and material per Article 42 of General Conditions and provide service for period of one (1) year from date of final acceptance by Owner.

B. Replace any defective workmanship or material developing within that time as soon as possible at no charge to Owner.

C. After completion of installation, manufacturer shall regulate and adjust equipment provided in this contract prior to final acceptance.

1.10 OWNER TRAINING

A. Pressure Relationship, Temperature and Control System Contractor shall have designated representative available to monitor/modify airflow control systems after systems have been started and are regularly used until Owner has completed on-site training specified.

B. Provide minimum of 8 eight hours of on-site training to Owner's representatives. Conduct training sessions during normal working hours after system start-up and acceptance by owner. Scheduling of training session(s) will be established by Owner and shall include both classroom and hands-on training. Portions of training may be performed before system is completely operational, but no sooner than 1 month before system is planned to be fully operational. Final training session shall be held after systems are complete, including all graphics programming.

C. Training sessions shall include, but not be limited to, the following topics:
   1. Explanation of control sequences. Include which sensors are used and how output device operates.
   2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
   3. Walk-through of Project to identify controller locations and general routing of network cabling.
   4. Review of operation and maintenance of hardware devices including controllers, instruments, and sensors. Include schedule for routine maintenance.

D. Instructions on how to monitor and operate system hardware and software, and how to change system set points, flow rates, etc and respond to alarms.

E. Review interface for troubleshooting using operator interface device.

F. Training sessions shall be conducted during separate visits to site from site visits for system adjustment, performance test and certification.

1.11 OPERATING AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements.

B. Operating and maintenance manuals shall provide descriptions of maintenance on all system components including sensors and controlled devices. These shall include Control Contractor's completion check list, inspection requirements, periodic preventative maintenance, cleaning methods and materials, troubleshooting guide, calibration instructions and tolerances, repair parts lists, and manufacturer representative's name, address, and phone number.

C. O&M Manuals shall also include interconnection wiring diagrams with identified and numbered system components and devices.

D. Provide the latest version of all standard software, including any software updates for period of one year, coinciding with warranty period. Beta released software shall not be used.

E. Provide all software tools needed to program, communicate with, or diagnose system controllers.

F. Provide software manual as specified in section 23 0923 1.3 C.

1.12 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements.

B. Submit revised shop drawings indicating all changes made during project including any changes to operating sequences or setpoints.

C. Update control diagrams to include all tuning parameters and setpoints applicable to systems as depicted as of date of system completion. This information shall be incorporated with sequence of operation of each system.

D. Record actual locations of control components including control units, temperature/humidity sensors, air terminals and any controlled devices on As-Built ductwork/piping plans provided by Mechanical Contractor.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Design of Contract Documents, are based on systems and equipment as manufactured by Phoenix Controls Corporation.

B. The airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical and non critical spaces using a Quality Management System registered to ISO 9001:2000.

C. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle costs.

D. Owner will select BAS and PRTACS system combination based on first cost, integration capabilities with campus Tridium system, operating characteristics, system capabilities, recommendations from Owner of previous system collaborations and Owner preferences.

2.2 GENERAL

A. Materials shall be new and unused and free from defects and imperfections.

B. Airflow control system shall be fully stand-alone for each individual patient room, operating room, or positive/negative pressurization space. System shall not use or rely on information from controllers in other areas or from outside controlled space to control functions within its control space. Refer to drawings for location of control panel for each space.

C. Electrically actuated terminal units shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on either the supply air or exhaust air manifold (within 0.3 to 3.0" WC). Air terminal units shall be balanced to conform to requirements of Section 23 0595 - Air Systems Test Adjust Balance.

D. Airflow control system shall use volumetric offset to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable. Offset airflow is indicated for each controlled space on Air Terminal Device schedule.

E. Control wiring and pneumatic tubing shall meet requirements of specification Section 23 0901 - Control Systems Integration.

F. Control panels shall be located near entry to each control space as shown on plans. Coordinate location of control panel with all trades to provide access to panel for maintenance. Provide communications jack as part of or adjacent to space temperature sensor to allow communication between laptop computer and control panel. Provide one control panel for each controlled space as shown on plans.

G. The airflow control system shall maintain specific airflow (±5% of signal) with a minimum 12 to 1 airflow turndown to ensure accurate pressurization at low airflow and assure maximum energy efficiency.

H. In the event of a power failure, airflow control devices shall fail to the last position and continue to maintain flow control within ±5% of signal within one second of a change in duct static pressure

I. Provide sound attenuator for each air terminal device. Refer to Section 23 3314 - Ductwork Specialties for sound attenuator specification.

2.3 PHOENIX CONTROLS SYSTEM

A. General:

1. The following requirements apply to Theris venture valves manufactured by Phoenix Controls Corporation.

B. Airflow Control Devices - General:

1. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2000.
2. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure-independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure regardless of the magnitude of pressure (from 0.3" WC to 3.0" WC) (74.7 Pa to 747 Pa) and/or flow change or quantity of airflow controllers on a manifolded system.
3. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than:

Pressure Drop Range	Airflow	Turndown	Valve Type
0.6- 3.0" WC	Devices up to 1,000 CFM (472 l/s)	20 to 1	Standard
	Devices up to 1,500 CFM (708 l/s)	16 to 1	Standard
	Devices up to 2,500 CFM (1,180 l/s)	12 to 1	Standard
	Devices up to 850 CFM (401 l/s)	17 to 1	Shutoff
	Devices up to 1,300 CFM (614 l/s)	14 to 1	Shutoff
0.3- 3.0" WC	Devices up to 550 CFM (260 l/s)	11 to 1	Standard
	Devices up to 1,050 CFM (496 l/s)	11 to 1	Standard

4. No minimum entrance or exit straight length of duct shall be required to ensure accuracy and/or pressure independence.
5. The airflow control device shall be constructed of one of the following types:
   a. **Class A**—The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure-independent springs shall be a spring-grade stainless steel. All shaft-bearing surfaces shall be made of a Teflon, polyester or PPS (polyphenylene sulfide) composite.

1). Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24-gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.

6. A low-speed electric actuator shall be used to modulate the airflow over the range of the specific valve size. The maximum time to modulate from minimum to maximum flow shall be less than 90 seconds. A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to maintain its last airflow position. This position shall be maintained until power is restored.
7. The shutoff airflow control device shall have shutoff and casing leakage of no more than:

Static Pressure Across Valve in Shutoff	**Airflow**	**Shutoff Leakage**	**Casing Leakage**
5.0 in w.c.	Shutoff devices up to 850 CFM (472 l/s)	6 CFM	0.12 CFM/ ft²
	Shutoff devices up to 1,300 CFM (708 l/s)	6 CFM	0.12 CFM/ ft²
	Low leakage shutoff devices up to 850 CFM (472 l/s)	0.005 CFM	0.010 CFM/ ft²
	Low leakage shutoff devices up to 1,300 CFM (708 l/s)	0.010 CFM	0.010 CFM/ ft²

C. Certification

1. Each airflow control device shall be factory characterized using NIST-traceable air stations and instrumentation having a combined error no greater than ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be characterized to ±5% of signal across the full operating range of the device. All flow data for any given device shall be stored at the factory and be available on presentation of a serial number within 24 hours. Flow data for all valves shall be stored at a location away from the factory for disaster recovery purposes.
2. Each airflow control device shall be marked with the room number, tag number, serial number, and model number. All information shall be stored by the manufacturer for use with as-built documentation.

D. Air Terminal Controllers:

1. One Theris controller shall be supplied for both the supply airflow control device and the corresponding exhaust air control device. The Theris controller shall be a microprocessor-based design and use closed-loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow
2. In flow tracking applications where an exhaust device is tracking a supply device, flow data for each device shall be downloaded to the Theris controller in the factory.
3. The airflow control device shall store its control algorithms in non-volatile, rewritable memory. The device shall be able to stand alone or to be networked with other room-level digital airflow control devices through an industry standard protocol.
4. Room-level flow tracking control functions shall be embedded in and executed by one controller mounted on one of the airflow devices.

5. The room-level control network shall communicate by using BACnet MS/TP protocol. The control device must meet the requirements of a BACnet Application Specific Controller (B-ASC), and be a BACnet Testing Laboratories (BTL) certified device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Files Functional Group
   b. Reinitialize Functional Group
   c. Device Communications Functional Group
      1). Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above.
      2). Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program object types.
6. The airflow control device shall use 24 Vac power +/- 15%, the industry standard.
7. The airflow control device shall be able to connect a commissioning tool. Every node on the network shall be accessible from the BACnet Building Automation System (BAS).
8. The airflow control device shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0–10VDC, 0–5 VDC, 4–20 mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of 3 inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0–10VDC or 0–20mA. Software shall include scaling features for analog outputs. Application controller shall include 24VDC power supply for use as power supply to external sensors.
9. The airflow control device shall include support for and communicate with intelligent room sensors provided with BAS system. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor.
10. The airflow control device shall meet the following agency compliance requirements- FCC Part 15 Subpart J Class A, CE and UL 916.

E. Control Functions:
   1. Control functions shall include room volumetric offset directional airflow control and temperature control, as well as respond to occupancy and emergency control commands

      a. Pressurization Control
         1). The airflow control system shall control supply and exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. The offset represents the air volume that enters or exits the room from the corridor or adjacent spaces.
         2). The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. This offset shall be adjustable from the BAS and locally through commissioning software installed on a laptop computer.
         3). The pressurization control algorithm shall consider networked and non-networked airflow control devices that consist of any number of constant volume devices where the total of the supply and exhaust devices may be included in the pressurization control algorithm.

4). The pressurization control algorithm shall be able to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

b. Temperature Control

1). The airflow control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The airflow control system shall support up to three separate temperature zones for each pressurization zone. The controller shall calculate separate cooling and heating set points based on a single writable set point from the BAS, with the option of a local offset adjustment.

2). Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with the supply and exhaust airflow devices responding simultaneously to maintain the desired offset. Heating shall be provided through modulating control of a properly sized control valve connected to the selected reheat coil.

c. Humidity Control

1). The airflow control system shall have an optional embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. The airflow devices shall have the ability to monitor the relative humidity level of the space and, based on a BAS writeable set point, develop a control signal to drive a humidification control circuit.

d. Occupancy Control

1). The airflow control system shall change the minimum ventilation and/or temperature control set points, based on the occupied state, to reduce energy consumption when the space is not occupied. Three occupancy modes shall be available: occupied, standby and unoccupied. The occupancy state may be set by either the BAS as a scheduled event, local occupancy switch, or override button. The airflow control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied mode for a predetermined interval. The local occupancy switch or bypass button shall be given priority over a BAS command.

e. Emergency Mode Control

1). The airflow control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow set point. The system shall support up to four emergency control modes. The emergency control modes may be initiated either by a local contact input or BAS command. The modes shall be as follows: Emergency Mode 1 (configurable), Emergency Mode 2 (configurable), Emergency Mode 3 (configurable), and Emergency Mode 4 (configurable).

2). Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

f. Airflow Shut-off Function

1). The air flow control venturi valves shown on the drawings and schedules as type SOV shall be capable of shut off function. Each device shall be capable of accepting a digital input to switch each individual air valve from the set point flow to shutoff position. This valve shall utilize an electric actuator with fail to last position operation. Feedback shall be available to indicate flow and shutoff. These valves shall also be capable of network operation and being commanded to shutoff position from the BAS.

F. Room Temperature Sensors:

1. Sensors shall be 10K ohm thermister type by ACI. Thermister shall incorporate jumpers and RJ-11 connector specific to the "Phoenix" option. Sensor shall include communication jack to allow remote programming of controller via laptop computer. Temperature sensors shall have remote sensor located in room general exhaust duct and adjustable setpoint adjustment and temperature adjustment in wall enclosure for each laboratory or laboratory support space and shall be programmable with adjustable deadband set point between 72°F and 78°F. Temperature sensor shall allow for room temperature input to BAS.

2.4 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. BACnet Interface

1. The airflow control system network shall interface digitally with the BAS via BACnet MS/TP. All room-level points shall be available to the BAS for programming, monitoring or trending.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install units as shown on drawings, schedules and details. Coordinate with Mechanical Contractor to verify appropriate ductwork configuration to allow for accurate measurement and control of airflow.

B. Pressure Relationship, Temperature and Airflow Control System manufacturer shall furnish, install and terminate all low voltage control wiring and 24 VAC power supplies. Pressure Relationship, Temperature and Airflow Control System manufacturer shall furnish and install pneumatic control tubing required for airflow control devices that are pneumatically operated.

C. Air Terminals and Reheat Coils:

1. Pressure Relationship, Temperature and Airflow Control System Contractor shall furnish to Division 23 Contractor air terminals, sound attenuators, reheat coils and access doors to install as shown on drawings and according to manufacturer's instructions. Mechanical Contractor shall install reheat coil control valves furnished by Temperature Control Contractor. Mechanical Contractor shall provide necessary ductwork transitions as required for mounting equipment provided by Airflow Control Contractor.
2. Mount actuators on same side of air terminal device as coil connections to ensure service access.
3. Connect air terminals to ductwork with removable type joints as detailed.
4. Transition from supply air terminal to reheat coil shall not exceed 15° per side.
5. Provide access doors for supply air terminals with reheat coils. Mount access door at inlet side of coil. Refer to Section 23 3314 - Ductwork Specialties for access door requirements.

D. Control and Power Wiring:

1. Pressure Relationship, Temperature and Airflow Control System (PRTACS) manufacturer shall provide control wiring from airflow control panel to and between other airflow control system components as required for complete and proper functioning, including but not limited to air terminals, control valves, sensors, transducers, controllers, panels, and interface modules.
2. Electrical Contractor will provide one spare 20-amp circuit at each emergency power electrical panel, serving control space. PRTACS supplier shall provide required conduit, wire, junction boxes, disconnect switches, and circuit breakers as specified in Division 26 as required to wire electrical panel to each airflow control panel.

E. Airflow Control Panels and Power Supplies:

1. Mount airflow control panels and power supplies in accessible location within pressure relationship controlled room as shown on plans.
2. Coordinate location of electrical power panels with Division 26 Contractor.

F. Airflow Control System Start-up:

1. System startup shall be provided by factory authorized representative of system manufacturer.
2. Coordinate timing of start-up with Mechanical Contractor to confirm HVAC Systems are operating as specified.
3. Startup shall be performed on complete pressure relationship, temperature and air flow control system and shall include calibration of each airflow control system component; check out of air terminals, actuators, temperature sensors, and verification that each system operates in compliance with specified control sequences.
4. Pressure Relationship, Temperature and Airflow Control System manufacturer shall set up system supply, and general exhaust air flows in cooperation with TAB Contractor. TAB Contractor will take required air flow measurements.
5. Pressure Relationship, Temperature and Airflow Control System manufacturer shall demonstrate that, with specified room offset, system maintains proper room directional air flows under both static and dynamic operating conditions, and can recover to proper flow direction within one second of change in room/system conditions such as closing an open door. Verification shall be provided by temporary visual indication, using smoke wand. If performance requirements can not be demonstrated, then airflow control system manufacturer shall be responsible for any costs and labor necessary to meet minimum performance requirements. Coordinate with and work in conjunction with TAB Contractor.

END OF SECTION

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SECTION 23 3713 DIFFUSERS, REGISTERS AND GRILLES

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 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

1.3 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.

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 as scheduled.

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 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. 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 as scheduled.

2.4 ADJUSTABLE LINEAR DIFFUSERS

A. Linear diffusers shall be extruded aluminum and furnished with frame type appropriate to installation with diffuser elements being removable from frame. Diffuser vanes shall provide both air pattern and flow rate adjustment with air pattern having full 180° adjustment. Diffuser vanes of single slot shall be segmented on 2 ft or 3 ft centers.

B. Diffuser models, lengths and slot sizes shall be as shown on drawings and/or as scheduled. Unless otherwise indicated, frame face shall have baked enamel or powder coat finish with color selected by Architect. Diffuser vanes and frame interior shall be finished in flat black.

2.5 FIXED BLADE LINEAR DIFFUSERS AND GRILLES

A. Linear diffusers and grilles to be extruded aluminum with frame type appropriate to sidewall, sill or ceiling installation as indicated.

B. Diffuser and grille models, lengths, blade spacing and blankoff strips to be as shown on drawings and/or as scheduled.

C. Diffusers used for supply air to be furnished with straightening or equalizing vanes. Blades to be fixed at 0 or 15° deflection as scheduled.

D. Unless otherwise indicated, diffusers and grilles shall have anodized aluminum finish with color selected by Architect.

2.6 PERFORATED SUPPLY DUCT DIFFUSERS

A. Exposed spiral galvanized steel duct constructed in accordance with Section 23 3114 - Ductwork.

B. Outlet patterns shall be 360° perforations designed for supply air distribution unless otherwise noted. Refer to diffuser schedules for special flow patterns requirements.

C. Perforation patterns shall be selected to achieve 50 cfm per square foot of face area with a 0.05” wc pressure drop.

D. Perforated supply duct diffusers used in exposed areas shall be factory spray painted with color selected by Architect. Color shall be semi-gloss white unless otherwise noted. Refer to diffuser schedules for other colors.

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

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SECTION 23-4114 FILTERS (FOR REFERENCE ONLY – OWNER PROVIDED)

PART 1 GENERAL

1.1 RELATED WORK

A. 23-7328 Factory Fabricated Custom Air Handling Units

1.2 REFERENCE

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

1.3 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; cfm, area, face velocity
   4. Efficiencies and initial/final pressure drop
   5. Materials of construction
   6. Dimensions
   7. Filter gauges data
   8. Manufacturer's installation instructions
   9. All other appropriate data

1.4 DESIGN CRITERIA

A. Filters shall have UL, Class I or Class II listing.

B. Holding frames or housings specified in this Section may be furnished by filter manufacturers listed below, or where applicable, as part of factory packaged air handling units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Camfil/Farr, Flanders Precisionaire, or Airguard unless otherwise noted under individual filter.

2.2 DISPOSABLE PANEL FILTERS (PRE-FILTERS)

A. Cam-Farr 30/30 or approved equal by American Air Filter, Eco-Air or Airguard.

B. Media shall be non-woven, cotton fabric material laminated to rigid backing to hold pleat formation, having minimum efficiency MERV 8 based on ASHRAE Test Standard 52.2 (average efficiency of 40% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Filters shall be UL Class 2 labeled.

C. Filter housing shall consist of air handling unit manufacturer's low velocity filter section, or holding frame, as scheduled. When holding frame is indicated, it may be furnished by, filter manufacturer or it may be contractor fabricated.

D. Media support shall consist of welded wire grid with 90% or more open face area. Grid shall be bonded to filter media.

E. Filter enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board bonded to filter pack. Standard sizes shall be 12" x 24" x 2" and 24" x 24" x 2".

F. Filters shall be capacity as scheduled. Clean filter pressure drop shall not exceed 0.28" WG based on 500 fpm face velocity.

2.3 DISPOSABLE RIGID CARTRIDGE TYPE AIR FILTERS (FINAL FILTERS)

A. Similar to Farr E-Series RIGA-FLO or equal by American air Filter, Airguard or Eco-Air.

B. High performance deep pleated, rigid, disposable type filters. Filters shall be constructed without use of steel components. Each filter shall consist of high efficiency media, enclosing frame, contour stabilizers on both air entering and exiting sides and support grilles. Filters shall be designed to withstand minimum differential pressure of 6” WG without structural damage to filter frame, seals or media. Filters shall be UL Class 2 labeled.

C. Media shall be high density microfine glass fiber laminated to non-woven synthetic backing to form a lofted filter blanket.

D. Media support shall be welded wire grid with effective open area of not less than 96%. Grid shall be bonded to filter media to eliminate media oscillation and pull away. Grid shall support media both vertically and horizontally. Contour stabilizers shall be permanently installed on both air entering and exiting sides of filter media pack to insure pleat configuration is maintained throughout life of filter.

E. Enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled to provide rigid and durable enclosure for filter pack. Frame shall be bonded to filter pack. Standard sizes shall be 12" x 24" x 12" and 24" x 24" x 12".

F. Filter thickness, size and capacity shall be as scheduled.

G. Filters shall have minimum efficiency MERV 11 based on ASHRAE Test Standard 52.2 (average efficiency of 60-65% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Initial resistance at 500 fpm face velocity shall not exceed scheduled pressure drop.

H. Filters shall have minimum efficiency MERV 14 based on ASHRAE Test Standard 52.2 (average efficiency of 90-95% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Initial resistance at 500 fpm face velocity shall not exceed scheduled pressure drop.

2.4 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS (FUTURE)

A. Filter size, capacity, and static pressure drop shall be as scheduled.

B. Filters to be individually tested and certified shall be 99.97% minimum efficient with handling 0.3 micron particles in accordance with DOP test method. DOP efficiency along with filter serial number and name of manufacturer shall be marked on filter.

C. Each filter element shall consist of glass fiber media, fire retardant epoxy or self-extinguishing neoprene rubber sealer and neoprene gasket all contained in suitable protected steel frame. Each filter element shall be constructed without use of spacers of any kind, including separators, tape, string or strips of medium by self-supporting pleating continuous sheet of formed, corrugated medium. Mount filters in side access housing or holding frames specified elsewhere in this section.

D. Filters to be listed or classified under UL 586 test standard.

2.5 CARTRIDGE CHARCOAL FILTERS (FUTURE)

A. Air filters shall be compact 12" deep adsorber type with combination sorbent/particulate removal media, impact-resistant plastic end caps, plastic vertical support channels, and a nominal 1" header for front or side-access applications.

B. Filter cartridge sizes shall be 24"x24"x12" except as required to maximize filter surface area, 24"x12"x12" cartridges shall be acceptable.

C. Filter media shall be specifically manufactured for the removal of molecular and particulate contaminants. Sorbent shall be broad spectrum grade of carbon incorporating Rapid Adsorption Dynamics (RAD) designed for the removal of a wide range of odors and VOCs.

D. The media shall be formed into uniform pleats using hot-melt separators, assembled into multi media packs and bonded into a high-impact resistant plastic frame to prevent air bypass. Filter assemble shall include after filter as necessary to prevent carbon dust from traveling downstream.

E. Resistance to airflow shall not exceed 0.48 inches w.g. at 500 feet per minute velocity.

F. The media shall have a particulate removal efficiency of MERV of 13 when tested per ASHRAE Standard 52.2.

2.6 FILTER HOLDING FRAMES

A. Frames shall be minimum 16 ga galvanized steel construction with provisions for assembly in a bank. Frames shall be suitable for filters scheduled and incorporate gaskets and spring clips to prevent air bypass.

2.7 LOW VELOCITY FILTER SECTIONS

A. Provide for factory packaged, air handling units and cabinet fans as indicated.

B. Housing shall consist of modular steel section with hinged access doors for filter replacement. Each housing shall be internally insulated by manufacturer or externally insulated in the field. Factory applied internal insulation shall have thermal resistance equivalent to that specified for duct in which housing is located, shall have internal vapor barrier, and shall have flame spread and smoke developed ratings as specified in Section 20 0700 - Mechanical Systems Insulation.

2.8 FILTER PRESSURE DROP GAUGES

A. Dwyer Series 2000 Magnehelic pressure gauge.

B. Unless otherwise indicated below, select scale range to be most appropriate to clean and dirty filter pressure drops.

Filter Type	Scale Range (inch WG)
Pre-Filters	0 - 1.0
Final Filters	0 - 2.0
HEPA filters	0 - 4.0
Charcoal filters	0 - 2.0

C. Provide gauges for each filter bank, including gauges across each individual filter bank in built-up rack assemblies, suitable for flush mounting in a panel, including air filter gauge accessory package for use with 1/4" OD copper tubing.

D. Provide 3/4" spacer at one 2' x 2' filter section between filter elements in built-up rack, adjacent to unit wall for placement of intermediate pressure probe.

2.9 REPLACEMENT FILTERS

A. Enough media for 3 filter changes shall be provided for each air handler (excluding HEPA and carbon filters), 2 construction sets and 1 final set. Media used during construction shall be replaced when system is air balanced. Filters shall be like new at the time of turn over to the owner.

2.10 FILTER CLIPS

A. Provide 2” long “D” style holding clips for pre-filters.

B. Provide ¾” long “D” style holding clips for final filters.

C. Provide swing bolt style holding clips with hand turn knobs for HEPA filters.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install filters as shown on drawings and according to manufacturer's instructions.

B. Provide supports as required and necessary clearance for changing filters.

C. Provide structural supports, outside casing and blank-off materials for all field assembled filter banks, and filter banks where housings are not furnished by filter manufacturer.

3.2 FILTER PRESSURE DROP GAUGES

A. Mount gauge near each filter bank and install static pressure sensors according to manufacturer's instructions.

B. Mount gauge on control panel.

END OF SECTION

SECTION 23-7328 FACTORY FABRICATED CUSTOM AIR HANDLING UNITS (FOR REFERENCE ONLY – OWNER PROVIDED)

PART 1 GENERAL

1.1 RELATED WORK

A. Section 20-0513 - Motors

B. Section 20-0529 – Pipe and Equipment Supporting Devices

C. Section 23-0550 - Vibration Isolation

D. Section 23-0902 - Control Dampers

E. Section 23-2116 - Pipe and Pipe Fittings

F. Section 23-2118 - Valves

G. Section 23-2120 - Piping Specialties

H. Section 23-3314 - Ductwork Specialties

I. Section 23-3400 - Fans

J. Section 23-4114 - Filters

K. Section 23-8216 - Coils

L. Section 23-8413 - Humidification Equipment

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

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

O. Section 26-2726 - Wiring Devices

P. Section 26-2816 - Enclosed Switches and Circuit Breakers

Q. Section 26-2913 - Enclosed Controllers

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

A. Shop drawings for all equipment including, but not limited to, the following:

1. Appropriate identification
2. Complete drawings showing plans and sections including details of construction
3. Overall unit dimensions and individual components and sections dimensions
4. Shipping and operating weight of unit and/or sections
5. Structural design load
6. Details of component support
7. Capacities/ratings
8. Materials of construction
9. Thermal and acoustical performance of wall, roof and floor panels
10. Pressure ratings and leakage ratings
11. Thermal break construction details and performance calculations or test data
12. Each component manufacturer's name, model number and data. (Refer to each component section for submittal requirements.)
13. Air leakage rates and test data
14. Wiring diagrams and terminal points for control panels provided with units
15. Manufacturer’s installation instructions
16. Air handling unit manufacturer’s local representative and phone number

1.4 DESIGN CRITERIA

A. For housings and floors operating under positive pressure (fan discharge side), maximum allowable deflection shall not exceed 1/200th of any span in any direction at + 10" WG.

B. For housings and floors operating under negative pressure (fan inlet side), maximum allowable deflections shall not exceed 1/200th of any span in any direction at - 10" WG.

C. Air handling unit manufacturer shall provide equipment as specified and install equipment furnished by others to result in complete and operational unit. Unit manufacturer shall assume single source responsibility for all air handling unit components and accessories.

D. Furnish units complete with fans, piping, valves, piping specialties, actuators, motors, coils, humidifiers, drain pans, filter sections, damper sections and interior lighting, meeting configuration and as shown on drawings, specified and as scheduled. All unit components shall meet this Section of specification and all requirements specified in each section and division listed under Related Work. Control dampers shall be provided by unit manufacturer. Control dampers actuators will be furnished by Control Contractor for factory mounting by unit manufacturer.

E. Unit performance shall be in accordance with ARI, Standard 430.

F. All materials shall meet NFPA 90A flame and smoke generation requirements.

G. All materials shall comply with FM Global insurance requirements.

H. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.

I. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure.

J. Motor furnished with fan shall not operate into motor service factor in any cases.

K. 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.

L. Air handling unit static pressure to take into consideration actual static pressure loss of components furnished within unit and any system effects due to unit arrangement and inlet and discharge connections.

M. Wire brush all welds with solvent and wipe clean all bare metal before painting.

N. Unit dimensions shall reflect space provided on plans including access allowances for equipment maintenance and overhead clearance requirements for stacked units located on raised structural platforms. All access aisle clearances shall be maintained as indicated on drawings to allow future AHU installation and replacement. Shipping splits shall allow installation of units within constraints of available access space.

1.5 FINAL CLEANING

A. Outside and inside of each air handling unit shall be thoroughly cleaned. Use industrial grade cleaners to remove construction dust, sheet metal mil finish or grease. All proposed cleaning materials shall have contents identified and approved prior to use. Cover unit openings with sheet metal or other proper material until ductwork is connected to maintain unit cleanliness.

1.6 MANUFACTURER QUALIFICATIONS

A. Air handling units shall be manufactured by qualified unit manufacturer that has been making custom units for at least 10 years, and shall carry manufacturer's nameplate. Unit manufacturer shall be held responsible for specified performance of units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Governair/Ventrol, Ingenia, TMI Climate Solutions, Air Flow Equipment, ClimateCraft or Trane Custom with operating characteristics as scheduled and physical dimensions as shown on drawings and/or detailed.

2.2 UNIT BASE

A. Unit base shall be fabricated from structural steel or galvanized formed steel.

B. Base shall be sized to provide sufficient height above floor to accommodate cooling coil drain trap height indicated on details. Additional steel base may be used as sub-base to provide the required trap height. Sub-base shall be provided by unit manufacturer.

C. Weld steel solid at connection points to assure rigidity. Size perimeter steel to allow for rigging and handling.

D. Locate and size base cross supports to support internal components.

E. Provide lifting lugs to perimeter base steel. Incorporate means of attaching cable or chain into each lug.

F. Base shall be split in maximum size pieces to allow for economical shipment to jobsite and placement within building. Provide bolting structural steel on both sides of split for field joining.

G. Unit base shall be primed and finished with rust inhibiting epoxy paint. Galvanized dipped or powder coating may be used in lieu of epoxy paint. If base rail is not galvanized dipped, then the bottom of the base rails need to be painted to avoid rust issues.

2.3 UNIT FLOOR

A. Unit floor shall be constructed to meet the maximum allowable deflection, and constructed of no lighter than:

1. 3/16” aluminum plate or 1/8” aluminum plate with an increase in floor supports for framing. Floor plate shall have diamond-tread.

B. Floor joints and seams shall be continuously welded water tight. Each section shall have turned up lip around section perimeter with welded corner to form drain pan type floor capable of retaining minimum 1-1/2” of water without leakage. Locate drain connection at lowest point of each pan type floor section. Connections shall extend through perimeter base channel and be welded water tight. Provide removable cap on each drain connection.

C. Weld flooring material to structural members below. Drive screw attachment is not acceptable.

D. Unit manufacturer shall field weld the unit floors as required to connect air handling unit shipping splits.

E. Entire floor including base drain pans shall be insulated on underside to have same thermal and acoustical performance specified for unit housing. Insulation shall be supported by minimum 20 ga galvanized steel liner with joints sealed to provide continuous vapor barrier.

F. Base Drain Pans:

1. Provide recessed drain pans as integral part of unit floor in pre-heating coils, outside air sections and humidifier sections.
2. Drain pans shall be constructed from minimum 16 ga 304 SS sheet, all seams continuously welded.
3. Drain pan shall be double sloped; pitched down in direction of air flow and pitched sideways to drain connection.
4. Locate drain connections at lowest point of pan, one on either end. Connections shall extend through perimeter base channel and be continuously welded to insure air-tight seal as well as eliminate requirement for backup wrench during field piping. Provide removable cap on each drain connection.
5. Refer to Cooling Coil Section for cooling coil drain pan requirements.

2.4 UNIT HOUSING

A. Unit housing shall be constructed of minimum 3" thick double wall panels meeting thermal, acoustical and structural requirements specified.

B. Panels shall utilize modular panel type construction. Panels may be self-supporting with internal support structure or supported by structural frame work.

C. Panel joints and seams shall be sealed with proper gasket and caulking to meet maximum allowable housing leakage rate specified.

D. Panel system, including service corridor where used, shall incorporate thermal break design at panel frames, joining mullions, supporting base, or corners. Thermal break is defined as prevention of condensation on outside surface of unit casing with 91°F dry bulb and 77°F wet bulb temperature in adjacent space and 50°F dry bulb temperature inside air handling unit.

E. Unit manufacturer shall submit, as part of shop drawings, details of thermal break construction and calculations or test data indicating that thermal break design will prevent condensation on outside surface of unit casing with specified air temperatures at outside of unit and specified air temperature at inside of unit.

F. Outer face of panels shall be constructed of no lighter than:

1. 16 ga galvanized steel.

G. Solid inner face of panels shall be constructed of no lighter than

1. 22 ga 304 SS sheet
2. All interior panel joints shall be sealed water and air-tight and suitable for low pressure washdown with a hose without wetting of the insulation.
3. Unit casing shall be insulated with minimum 3 pcf density glass fiber, 2.5 pcf density polyisocyanurate, or 3 pcf density urethane foam insulation. Composite panel shall have heat transfer factor not greater than 0.06 Btu/hr/sq ft/°F. All products as applied shall meet NFPA 90A possessing flame spread rating of not over 25, fuel contributed rating of not over 50 and smoke developed rating of not over 50.

H. Use solid inner surface for all sections.

I. Provide center vertical partition to divide units into modules, as detailed on drawings. Partition panels shall be same construction as housing wall panels except both faces be constructed of no lighter than 16 ga solid galvanized steel.

J. Provide blank-off panels with proper gaskets and sealants to prevent air bypass around equipment such as filters, coils, humidifiers and sound attenuators. Blank-off panels shall be constructed of galvanized steel no lighter than 16 ga unless otherwise noted. Blank-off panels at cooling coil sections shall be insulated with 3/4" thick insulation similar to AP Armaflex SA Duct Liner. Do not insulate blank-off panels between cooling coils located above drain pans.

K. Panel manufacturer shall have published literature available stating sound absorption coefficient of panel system obtained using ASTM method of Test for Sound Absorption of Acoustical materials in

L. Reverberation Rooms (ASTM Designation C423-66), and sound transmission loss obtained using procedures conforming to ASTM Designation E90-70, E413-70T and other pertinent standards.

1. Sound Transmission Loss in accordance with ASTM E90 shall equal or exceed the following:

	Octave Band Center Frequency (Hz)					
	125	250	500	1000	2000	4000
Transmission Loss (dB) of 4" Panels	21	24	34	44	51	53

2. Sound performance tests must be documented by independent laboratory (ETL, Riverbank Laboratories, Kideras Labs, etc.).

M. Manufacturer shall have published literature available describing load-carrying capabilities and thermal characteristics of the panel system.

2.5 ACCESS DOORS

A. Each unit section shall have 24” x 72” access door, unless shown differently on drawings.

B. Fan section access door shall be sized to allow removal of fan wheel and motor through door, but not smaller than 30” x 72”. If access door needs to be wider than 36”, removable access panel may be provided.

C. Access doors and door frames shall have similar thermal break construction as specified under Unit Housing.

D. Access doors shall be same construction as housing panels.

E. Access doors located downstream of cooling coils shall be true thermal break design with no metal to metal contact.

F. Access doors shall be guaranteed tight closing through use of seals around entire periphery. Provide neoprene gasket between door frame and housing for air tight seal.

G. Each access door shall contain 1/4" thick wire glass or double glazed tempered glass window minimum size of 12" x 12" or 12" round. Window shall be double paned with vapor seal construction.

H. Each access door shall be furnished with corrosion resistant metal hinges or continuous piano hinge and shall have at least 2 stainless steel or aluminum alloy handles operable from either side.

I. Doors shall open against higher air pressure to affect seal.

2.6 ACCESS SECTIONS

A. Access sections shall allow minimum of 30” between adjoining equipment. Provide access doors as indicated on the plans.

2.7 REMOVABLE ACCESS PANELS

A. Removable access panels shall be provided as indicated on drawings and where equipment removal is not possible through access door. Removable panels shall be same construction as housing panels.

2.8 AIR MIXING SECTION

A. Provide air mixing devices as scheduled and per Section 23-3314 - Ductwork Specialties, with proper bulk needs and distances to dampers and coils per manufacturer’s recommendations.

2.9 FILTER SECTIONS

A. Filters shall be provided as specified and scheduled. Holding frames shall be installed by unit manufacturer to raise filters off floor and to prevent leakage as specified by unit manufacturer.

B. Provide space in prefilter section, downstream of prefilters, for installation of future carbon filters.

C. Each filter section shall have individual pressure gauges.

2.10 PREHEAT COIL SECTION

A. Provide preheat coils, piping and internal piping as specified and indicated on drawings.

B. Install coils, piping, and specialties not to block face area of coils. Terminate piping outside of unit casing for connection by Trade Contractor. Provide necessary pipe supports and hangers.

C. Coil pull access is not available on both sides of units, therefore coil flanges, mounting, and blank-off provisions shall be arranged for upstream or downstream face pull. Refer to drawings and coordinate with internal component arrangement. Coil sizes and quantities at each unit shall allow for coil pull through access space shown on plans.

D. Each coil shall be supported by galvanized steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Blank-off panels shall be galvanized steel sheets with insulation as specified.

2.11 COOLING COIL SECTIONS

A. Provide cooling coils, piping and piping specialties specified, and indicated on drawings.

B. Install coils, internal piping, and specialties not to minimize blockage of face area of coils. Terminate piping outside of unit casing for connection by Trade Contractor. Provide pre-insulated pipe supports. Refer to spec 20 0529 for requirements.

C. Each coil shall be supported by 304 stainless steel frame which is independent of unit casing. Support frame shall allow individual coil removal without disturbing any other coil or piping to any other coil. Coils shall be removable through unit access doors or removable access panels. Blank-off panels shall be 304 stainless steel sheet with insulation as specified.

D. Coil pull access is not available on both sides of units, therefore coil flanges, mounting, and blank-off provisions shall be arranged for upstream or downstream face pull. Refer to drawings and coordinate with internal component arrangement. Coil sizes and quantities at each unit shall allow for coil pull through access space shown on plans.

E. Each coil support shall include minimum 16 ga 304 stainless steel all welded condensate drain pan extending min. 4", but no more than 12" downstream of coil face. Each drain pan shall have sufficient depth to hold condensate water but not less than 2”. Drain pan shall be sloped in 2 directions (pitched down in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4" per foot slope. Drain pan shall be individually piped down to drain pan located below, and bottom drain pan to be piped to hub drain at exterior of unit. Drain connection opening shall be flush with bottom of pan. Side pan connection located at lowest point of pan may be used only where bottom pan connection cannot be used. Drain pipe shall be 304 stainless steel with sufficient size, but not less than 1-1/2”.

F. Instead of drain pan under bottom coil, recessed pan, integral with unit floor shall be used. It shall be constructed as specified above including thermal insulation and drain lines, and shall incorporate required drain trap height.

2.12 FAN SECTION

A. Fan and motor shall be provided as scheduled and meet requirements of appropriate Specification Sections.

B. Fan and motor shall be factory mounted on vibration isolation equipment meeting requirements of Section 23 0550 - Vibration Isolation. Vibration base shall include integral adjustable motor base. If inertia bases are required, provide required concrete in factory.

C. Motor Removal:

1. For motors 5 hp and larger, provide motor removal rail sized for L/400 deflection when fully extended and subjected to weight of motor at furthest extreme position.
2. Removal rail shall be mounted in fan section, centered with the fan section access door, perpendicular to side of AHU.

3. Removal rail shall be designed with roller so motor can be fully removed from unit to distance equal to the motor diameter plus minimum of 6", and lowered onto dolly with traversing arm able to freely move while carrying motor weight.
4. Motor shall be able to be removed through access door or access panel.

D. Fan Array:

1. Fan array system shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for duty specified. Fans shall be selected to deliver scheduled airflow quantity at scheduled operating total static pressure and scheduled fan/motor speed. Fan array shall be selected to operate at system total static pressure that does not exceed 90% of scheduled fan's peak static pressure producing capability at scheduled fan/motor speed. Each fan/motor cube shall include 11 ga, A60 Galvanized steel intake wall, 14 ga spun steel fan inlet funnel, and 11 ga G90 Galvanized steel motor support plate and structure. Fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. Motors shall be standard pedestal mounted type, T-frame motors selected at specified operating voltage, rpm, and efficiency as needed to meet performance requirements. Motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance. Maximum allowable Fan motor size shall be 15HP.
2. Fan array shall provide uniform air flow and velocity profile across entire air way tunnel cross section. Airflow and velocity shall not exceed scheduled cooling coil and/or filter bank face velocity when measured at a point 12" from intake side of fan wall array intake plenum wall, and distance of 48" from discharge side of fan wall intake plenum wall.
3. Provide partition between fans to minimize system effect.
4. Provide structural frame to support upper fans with solid floor panel partition between fans as shown on drawings to minimize system effect.
5. Each fan/motor cube shall be equipped with metal grating fan outlet guard.
6. Each fan in array shall be provided with back flow prevention means that produces less than 0.10" of static pressure drop and/or system effect when that fan is enabled. Any such system effects and/or pressure drops shall be submitted and included as component in determining fan system total static pressure as submitted. Manufacturer's pressure drop ratings of any such equipment, developed from straight run test conditions will not be accepted.
7. Fan array shall be sized such that upon single fan failure, remaining fans could ramp up and provide same 100% design capacity.
8. Provide local electrical disconnect and overload protection for each fan.
9. Contractor shall provide all wiring to air handling unit components that require power.

2.13 HUMIDIFIER SECTION

A. Provide humidifiers, piping and supports as specified, and indicated on drawings. Terminate piping outside of unit casing for connection by Trade Contractor.

B. Size and locate humidifier distribution tubes to receive uniform air flow on entire tube.

C. Provide required absorption distance between humidifier and downstream equipment or housing wall.

2.14 BIPOLAR IONIZATION

A. Provide bipolar ionization, similar to Global Plasma Solutions needle point ionization system, upstream of cooling coils.

B. Provide ion detector, similar to Global Plasma Solutions iDetect, to provide BAS status of the ionization system.

2.15 DISCHARGE AIR SECTION

A. Provide with framed discharge opening or spun bellmouth fitting conforming to size and configuration of the ductwork.

2.16 CONTROL DAMPERS

A. Refer to Section 23 0902 - Control Valves and Dampers for control dampers.

2.17 FLOOR OPENING PROTECTION

A. Floor openings shall have safety grates using 1" x 1/8" steel bar stock on 1-1/4" center spacing. Grates shall have same finish as floor. Provide 1-1/2" lip of galvanized steel at entire perimeter of opening.

2.18 CONTROLS

A. Control devices shall be by same manufacturer providing control devices for the remainder of the building.

B. Control devices will be furnished by Control Contractor and shall be field installed by Trade Contractor and as described in control section of specifications.

2.19 TESTING

A. Owner and/or Owner's representative may elect to witness tests. Notify Owner and/or Owner's representative of test date at least 2 weeks in advance. Submit certified test data to Engineer for approval.

B. Unit manufacturer shall provide factory tests to verify casing leakage after units are assembled.

C. Unit manufacturer and installing contractor shall jointly provide field tests to verify casing leakage after units are installed at jobsite. Coordinate with Electrical Contractor for power to unit test fan.

D. Casing leakage tests shall verify that unit casing leakage is less than 0.5% of design air flow at one and a half times design total static pressure (TSP).

1. Seal duct openings in positive pressure section. Connect this section to fan developing 1-1/2 times the design positive static pressure and read air flow of this fan using approved air flow measuring device. Fan air flow measurement shall be considered casing leakage of this Section.
2. Seal duct openings in suction side of unit. Connect this section to fan developing in 1-1/2 times the design negative static pressure and read fan air flow of this fan using approved air flow measuring device. Fan air flow shall be considered casing leakage of this Section.
3. Conduct casing leakage test individually for each air handling unit. Total casing leakage shall be calculated as sum of positive pressure section leakage and negative pressure sections leakage. Total casing leakage shall not exceed the allowable rate specified above.

E. Unit manufacturer shall provide factory panel deflection test. Conduct this test in conjunction with casing leakage testing.

1. Panel deflection test for panels under positive pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG positive, whichever is greater.
2. Panel deflection test for panels under negative pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG negative, whichever is more negative.
3. Deflection shall be measured at 2 points for positive pressure sections and 2 points for negative pressure sections (total 4 points at panel seams) at mid-point of panel height

2.20 ELECTRICAL SERVICE

A. Provide adequate lighting and switching so equipment can be observed and maintained in safe manner. Each unit section shall contain a minimum of one light fixture. Sections wider than 12 ft shall have multiple light fixtures with maximum spacing of 6 ft.

1. Provide light switch with pilot light for each access section. Locate switch near access door.

2. Provide timer for light switch to automatically turn off lights after preset time. Timer shall be similar to Intermatic Model FF2H with 0-2 hour range and hold feature to override automatic shut-off function.

3. Light fixtures shall be: LED type. Provide bulbs for each fixture.

B. Lights, switches, convenience outlets, wiring and conduit shall meet requirements of appropriate specification sections of Division 26.

1. Provide minimum of two convenience outlets on each unit, spaced evenly over length of unit.

C. Wiring and conduit inside of unit shall be provided by unit manufacturer. Conduit shall be EMT and meet requirements of NEC and appropriate specification sections of Division 26. Provide junction box for each motor at outside of unit wall and provide single point of connection for both 480V, 3-phase and 120V, single-phase power for connection by Electrical Contractor.

D. PVC coated LFMC is not allowed in environmental air plenum spaces or air handling equipment

E. Seal electrical penetrations through unit air-tight.

2.21 PIPED SERVICE

A. Piping and equipment installation inside the unit shall be complete. Piping shall be installed and tested per appropriate specification section. Unit manufacturer shall be responsible for any leaks, which occur in unit during system testing which occurs before system startup.

B. Extend piping for each coil and humidifier if used through panel casing. Terminate piping with flange for pipe 2-1/2" and larger or threaded connection for pipe 2" and smaller with caps.

PART 3 EXECUTION

3.1 INSTALLATION

A. Units shall be assembled in modules in unit manufacturer's plant to allow for testing of complete unit.

B. Unit manufacturer shall supervise installation of units and all field joining of the modules, including and sheet metal, electrical and piping.

C. Joints in floor between modules shall be fully welded to be air and water tight.

D. Unit manufacturer shall provide and install all equipment within unit as specified and/or scheduled, including fans, motors, coils, humidifiers, dampers, sound attenuating devices, piping, piping specialties, ductwork specialties, lights, switches and all equipment necessary to complete air handling equipment contained within housings. Mechanical and electrical connections (i.e., piping and conduit) shall be stubbed through housing so that appropriate contractor may provide service to air handling unit. Electrical wiring and control wiring shall terminate in junction boxes on accessible side of unit.

E. Provide structural steel sub-base as required. Refer to Unit Base in Part 2.

F. Field mounting of any equipment on housing walls or roof is not allowed without prior approval of Engineer. No field mounting of any services that will restrict access to fan and coil sections is permitted.

G. Unit manufacturer and installing contractor shall coordinate with other trade Contractors, all necessary requirements to assure proper air handling unit installation including module sizes necessary for installation of units within space available and final housekeeping pad dimensions.

H. Piped services to units, including electrical conduits, shall not cover fan and coil access sections.

3.2 INSTRUMENT TEST HOLES

A. Provide instrument test holes at air entering and air leaving side of all internal air handling unit components for static pressure differential or temperature measurements. Refer to Section 23-3314 - Ductwork Specialties for instrument test holes.

3.3 PROTECTION OF OPENINGS

A. Protect openings on housings during construction against entry of foreign matter and construction dirt.

3.4 FIELD TESTING & COMMISSIONING

A. Unit manufacturer and installing contractor shall jointly perform field casing leakage tests on each completed housing assembly as previously specified and shall be responsible for repair of all leaks. Submit certified test data to Engineer for approval.

B. Unit manufacturer shall be present for air handling unit commissioning. Coordinate date and time of commissioning with construction manager.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

D. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 23-8214 HEATING AND COOLING TERMINAL DEVICES

PART 1 GENERAL

1.1 RELATED WORK

A. Section 20-0513 - Motors

B. Section 23-8216 - Coils

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

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. 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. All other appropriate data

1.4 REFERENCE STANDARDS AND DESIGN CRITERIA

A. Duct Reheat Coils: Ratings shall be certified in accordance with ARI Standard 410.

B. Finned-Tube Radiation: Ratings shall be IBR certified.

C. Convectors: Ratings shall be in accordance with Commercial Standard CS 140.

D. Fan Coil Units: Ratings shall be certified in accordance with ARI Standard 440.

E. Units including electrical work shall be UL listed.

PART 2 PRODUCTS

2.1 DUCT REHEAT COILS (HOT WATER)

A. Manufacturers: Carrier, Trane, McQuay, Marlo, Temtrol, or Heatcraft.

B. Coils shall be constructed of 1/2" or 5/8" OD copper tubes with aluminum fins suitable for minimum working pressure to 200 psig and temperatures to 220°F.

C. Coils having steel nipples for connection are not allowed.

D. Coil fins shall be continuous serpentine or plate fin type.

E. Coil headers shall be cast iron with tubes expanded into headers or heavy seamless copper with all tubes brazed to header.

F. Casing shall have G90 galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

G. Coil frame shall be suitable for drive slip or flange and gasket connection to ductwork.

2.2 FIN TUBE RADIATION

A. Manufacturers: Slant/Fin, Sterling, Trane, Vulcan or Rittling.

B. Heating elements shall be constructed of aluminum fin on copper tube or steel fin on steel tube as scheduled, supported on wall mounting brackets with slide cradles 3 ft on center for free expansion without noise.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install units as indicated on drawings, and according to manufacturer's installation instructions.

B. Install branch piping to each unit with minimum of 3 elbows to allow for expansion and contraction.

C. Unless otherwise shown on drawings, mount vertical type wall mounted heating units 12" above finished floor.

3.2 DUCT REHEAT COILS

A. Comb out fins when bent or crushed before enclosing coils in ductwork. Clean dust and debris from each coil to ensure its cleanliness.

B. Seal or gasket coil connection to ductwork to meet maximum allowable leakage rate specified in Section 23-3114 - Ductwork, Part 3.

C. Unless otherwise specified, connect piping to coils with multiple rows for counter-flow arrangement.

3.3 FIN TUBE RADIATION

A. Install dirt guard gasket to mounting strip or caulk along top of mounting strip.

B. Unless otherwise shown on drawings, mount units with manufacturer's recommended minimum height above finished floor to provide capacities scheduled.

3.4 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 23-8216 COILS (FOR REFERENCE ONLY – OWNER PROVIDED)

PART 1 GENERAL

1.1 RELATED WORK

A. Section 23 7328 – Factory Fabricated Custom Air Handling Units

1.2 REFERENCE

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

1.3 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. Flow rate and pressure drop
   5. Materials of construction
   6. Dimensions and weights
   7. Manufacturer's installation instructions
   8. All other appropriate data

1.4 DESIGN CRITERIA

A. This Section covers coils in factory-packaged air handling unit, custom air handling units and field-erected air handling units.

B. Coil sizes, capacities, configuration and operating characteristics to be as shown on plans and/or as scheduled. Coil performance data shall be certified in accordance with ARI Standard 410.

C. Temperature profile of discharge air from entire coil face shall be uniform within 12" of coil face.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Buffalo, Carrier, McQuay, Trane, Marlo, Heatcraft, Aerofin, RAE, or Temtrol.

2.2 HOT WATER COILS

A. Coils shall be constructed of 0.035" tube wall, 1/2" or 5/8" OD seamless copper tubes with 0.0095” aluminum fins suitable for working pressures to 200 psig and temperatures to 220°F. Coils shall be tested at 250 psig under water.

B. Coil fins shall be continuous serpentine or plate fin type.

C. Coil headers shall be cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

D. Casings shall be minimum 16-gauge galvanized steel having galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

E. Coils shall be equipped with bronze spring turbulators where required to provide capacities indicated.

2.3 CHILLED WATER COILS

A. Coils shall be constructed of 0.035" tube wall, 1/2" or 5/8" OD seamless copper tubes with 0.0095" aluminum fins suitable for working pressures to 250 psig. Coils shall be tested at 250 psig under water.

B. Coil fins shall be continuous plate fin type.

C. Coil headers shall be constructed of cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

D. Casings shall be minimum 16 ga stainless steel having stainless steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.

E. Select coils for tube velocity not less than 3.0 fps.

F. Maximum allowable fin spacing shall be 10 fins per inch. Coil depth shall not exceed 8 rows.

PART 3 EXECUTION

3.1 GENERAL

A. Install coils as indicated on drawings and/or as detailed. Pitch coils for proper drainage according to manufacturer's installation instructions. Install shims as required.

B. Clean oil film from coil fins with hot water/detergent as recommended by coil manufacturer.

C. Comb out fins when bent or crushed before enclosing coils in housing. Clean dust and debris from each coil to ensure its cleanliness.

D. Provide flanges or joints in piping to facilitate coil removal. Unless otherwise specified, pipe coils for counter flow arrangement.

E. Provide air vent and drain valve at each water coil.

END OF SECTION

SECTION 23-8413 HUMIDIFICATION EQUIPMENT (FOR REFERNECE ONLY – OWNER PROVIDED)

PART 1 GENERAL

1.1 REFERENCE

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

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturing company shall have five (5) years experience with application of the specified humidification/evaporative cooling system for HVAC Systems.
   2. Manufacturing company shall have field service support and local representation to provide continuing support of humidification/evaporative cooling system.

B. Codes and Standards:
   1. UL and NEMA Compliance: Provide electrical components required as part of evaporative cooling system, which are listed and labeled by UL and comply with NEMA Standards.
   2. Provide electrical control panels assembled and labeled in UL qualified facility.
   3. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of evaporative cooling system.
   4. International Mechanical Code and State Mechanical Code Rules.

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. CV of control valves
   6. Absorption distances
   7. Dimensions
   8. All other appropriate data
   9. Electrical data and wiring diagrams for electric type humidifiers
   10. Maintenance data
   11. All other appropriate data
   12. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating pipe routing, nozzle locations, solenoid valves, dimensions, weight loadings, required clearances, and methods of assembly of components.

1.4 WARRANTY

A. Provide one (3) year manufacturers warranty for replacement of defective parts and one (1) year contractor's warranty for installation of replacement parts.

PART 2 PRODUCTS

2.1 STEAM HUMIDIFIERS

A. Manufacturers: Pure Humidifier Co., Armstrong, Dri-Steem, or Nortec

B. Unit shall be of steam jacketed manifold type, providing clean, dry steam humidification without condensate drip or objectionable steam noise.

C. Furnish unit complete with control valve, inlet strainer, inverted bucket trap or F & T trap according to manufacturer's recommendation.

D. Humidifiers shall be designed for complete absorption of steam within 18" inches of distribution grid.

E. Provide temperature switch to prevent humidifier from operating before start-up condensate is drained.

F. Provide multiple dispersion tubes where indicated or required for uniform steam distribution.

G. Steam Control Valve:

1. Control valve shall be normally closed modulating type with equal percentage flow characteristic from closed to approximately 30% open and linear flow characteristic above 30% open. Valve trim shall be stainless steel and designed to resist erosion of seat and plug. Refer to Section 23-0902 for actuator requirements.
2. Control valve full capacity shall not exceed scheduled humidifier capacity by more than 20%. Control valve rangeability (ratio of maximum controllable flow to minimum controllable flow) shall be tested in accordance with ISA 575.11 flow characteristic standards and shall be 10:1 minimum.

H. Humidifier Dispersion

1. Steam dispersion panel similar to DriSteem Ultra-Sorb:
    a. Factory-assembled steam dispersion panel shall include the following components:
        1) Steam supply header/separator
        2) Condensate collection header
        3) Steam dispersion tubes spanning distance between two headers
    b. Each dispersion tube shall be fitted with steam discharge tubelets inserted into tube wall. Each tubelet shall be made of thermal-resin material designed for high steam temperatures. Two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.
    c. Each tubelet shall extend through wall of and into center of dispersion tube and contain steam orifice sized for its required steam capacity.
    d. Each packaged humidifier panel assembly of tubes and headers shall be contained within galvanized metal casing to allow convenient duct mounting, or to facilitate stacking of and/or end-to-end mounting of multiple humidifier panels in ducts or air handling unit casings.
    e. Tubes and headers shall be 304 stainless steel and be Heli-arc welded.

PART 3 EXECUTION

3.1 STEAM HUMIDIFIERS

A. Mount units in air handling units as indicated on drawings. Provide additional support for distribution manifolds as recommended by manufacturer.

B. Install steam and condensate branch lines with minimum of 3 elbows to allow for expansion and contraction. Use pipe size as indicated on drawings or as recommended by manufacturer, whichever is larger. Ream pipe and blow out at full steam pressure before connection to humidifier.

3.2 COMMISSIIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 26-0000 GENERAL ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning 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 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, 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 exact dimensions.

G. Where architectural features govern location of work, refer to architectural drawings.

H. Work shall be performed in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.3 RELATED WORK

A. Temporary Services:

1. Refer to Division 01 - Temporary Facilities and Controls.

B. Continuity of Service:

1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
2. When interruption of services is required, persons concerned shall be notified and shall agree upon time.

C. Demolition:

1. Division 02 - Selective Demolition.
2. Perform demolition as required to accomplish new work.
   a. Remove abandoned wiring to source of supply. Wiring and conduit shall be extended where necessary to maintain circuit continuity to areas beyond the demolition scope area.
   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.

D. Cleaning and Repair

1. Clean and repair existing materials and equipment that remain or is to be reused.
2. Panelboards.
   a. Clean exposed surfaces and check tightness of electrical connections.
   b. Replace damaged circuit breakers and provide closure plates for vacant positions.
   c. Provide typed circuit directory showing revised circuiting arrangement.
3. 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, drivers, and broken electrical parts.

E. Concrete Work:

1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
2. Concrete shall comply with Division 03 - Concrete.
3. Provide anchor bolts, metal shapes and templates to be cast in concrete or used to form concrete as required for anchoring and supporting electrical equipment.
4. Provide vibration isolators at concrete housekeeping pads.

F. Painting:

1. Painting of electrical equipment will be done under Division 09 unless specified otherwise or is to be furnished with factory applied finish coats.
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 1 can of touch up paint for each factory finish, which will be final finished surface of product.

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. 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.
22. University of Kentucky CPMD Design Standards
23. University of Kentucky - Communications and Network Systems – Telecommunications Standards

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

1.6 LISTING

A. Material installed on project shall bear UL label or be UL listed, unless UL label or listing is not available for that type of material.

B. Other nationally recognized testing agencies, acceptable to AHJ, are approved.

1.7 ENCLOSURES

A. Typical NEMA Enclosures and Usage

1. NEMA 1 - Indoors. Falling dirt.
2. NEMA 3R - Outdoors. Rain, snow, sleet.
3. NEMA 4X - Same as NEMA 4 - Outdoors plus corrosion resistant.
4. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
5. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
6. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.

1.8 SUBMITTALS

1. B.A.S. HCP Boxes.

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. Submittal tracking number is to include the respective specification number.
5. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
6. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
7. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Clearly mark and note submittal accordingly.
8. Submit complete record of required components when luminaires, equipment and items specified include accessories, parts and additional items under one designation.
9. Include wiring diagrams for electrically powered or controlled equipment.
10. Submit electrical equipment room layouts drawn to scale, including equipment, raceways, accessories and required working clearances. Submit electrical equipment room layouts concurrently with electrical distribution equipment submittals.
11. 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.
12. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
13. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.

14. "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.
15. Unless specifically requested in Division 26 technical sections, submittals of coordination drawings will be returned without review.Certificates and Inspections:

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 1 hard copy and 1 electronic copy 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. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
   c. CD ROM's of O&M data with exploded parts lists where available
   d. Phone numbers and addresses of local parts suppliers and service companies
   e. Internet/WEB page addresses where applicable
   f. Wiring diagrams
   g. Start up and shut down procedure
   h. Factory and field test records
   i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. O&M manuals and instructions to Owner shall be provided45 days after equipment approval.

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.

1.9 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
   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 temperature control wiring
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 shall show number and HP rating of motors furnished by others, together with their actuating devices. Should any change in size, HP rating 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. Periodically as work progresses or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.10 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 for 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 Owner 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. Product substitutions are not allowed.

PART 3 EXECUTION

3.1 GENERAL

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

B. Division 26 Contractor shall provide Communications grounding and bonding infrastructure as specified and shown on plans, including but not exclusive to interconnecting ground cables.
   1. Division 27 Contractor shall provide and terminate Communications grounding conductors from Division 27-provided equipment to the closest Communications Grounding Busbar located in each of the IDF, and EIDF rooms.

C. Division 27 Contractor shall provide all Communications pathway infrastructure as specified and shown on plans, including but not exclusive to back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

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 above grade, interior locations 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 "CS" for poured wall openings or “modular” for cored and precast 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.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required, to provide access shall be provided at no additional cost to Owner.

B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Section 08 3113 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for the purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.

D. Provide necessary coordination and information to the Trade Contractor under Section 08 3113 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions, without limitations.

E. 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.

F. Verify door swings before installing room lighting switch boxes and install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

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

B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.

C. Do not support equipment or luminaires from metal roof decking.

3.6 SUPPORT PROTECTION

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

B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.7 HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for all floor-mounted equipment.

B. Pads shall be 3.5" high and be 2” wider and longer than equipment it supports.

3.8 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. Testing shall be in accordance with Section 26 0812 Power Distribution Acceptance Tests.

B. When testing is to be witnessed by Architect/Engineer or Inspector, notify them at least 10 days prior to testing date.

C. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials.

D. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

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

F. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.9 START-UP

A. Systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation.

1. This includes "Owner-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

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

C. Contractor shall provide services of technician/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.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.10 CLEANING

A. Clean systems after installation is complete.

B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.

C. Where louvers are provided 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 26-0519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26-0000 - General Electrical Requirements

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

C. Section 26-0533.13 - Surface Metallic Raceway System

D. Section 26-0553 - Electrical Systems Identification

E. Section 26 0812 Power Distribution Acceptance Tests

F. Section 26 0813 Power Distribution Acceptance Test Tables

G. Section 28-3116 - Multiplexed Fire Detection and Alarm Systems

1.2 REFERENCE

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

1.3 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.

1.4 REFERENCE STANDARDS

A. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

B. ASTM B 1 – Standard Specification for Hand-Drawn Copper Wire.

C. ASTM B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

D. NEMA WC 3 – Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81).

E. NEMA WC 5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-61-402).

F. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-668).

G. NFPA 70 – National Electrical Code.

H. UL 44 – Thermoset-Insulated Wires and Cables.

I. UL 83 – Thermoplastic-Insulated Wires and Cables.

J. UL 486A-486B – Wire Connectors.

K. UL 486C – Splicing Wire Connectors.

L. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.

M. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

1.5 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.

1.6 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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store 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 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. American Insulated Wire Corp.; a Leviton Company

B. General Cable Corporation

C. Senator Wire & Cable Company

D. Southwire Company

E. VFD Cable: Aetna Insulated Wire, Amercable, General Cable, Southwire

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; Type THHN, THWN, THHW.
   2. Thermoset-insulated wires and cables: NEMA WC 3, UL 44; Type XHHW-2.

B. VFD Cable:
   1. Cable
      a. 600V/2000V rated, high stranded tinned copper conductors, shielded, engineered for use with Variable Frequency Drives.
      b. Insulation shall be rated for 90 degrees Celsius Wet/Dry operating temperature.
   2. Conductors
      a. Conductor shall be annealed fine wire flexible high strand count tinned copper or standard Class B stranded bare copper.
      b. Three (3) phase conductors, three (3) ground conductors. Each of the three ground conductors shall be the same size as the single ground conductor shown on the drawings.
   3. Insulation
      a. Flame-Retardant Cross-Linked Polyethylene.
      b. Conductors shall be cabled together. Ground conductors shall be symmetrical. Fillers shall be included as necessary to make the cable round.
   4. Shielding
      a. The following are acceptable:
         1) Overall tinned copper braid plus aluminum/polyester tape foil, 100% coverage.
         2) 5mil helically applied copper tape.
         3) Impervious corrugated welded continuous armor.
   5. Jacket
      a. Flame-retardant Thermoplastic, suitable for 90°C use.
   6. Termination Kit
      a. Pre-sized and pre-formed specifically for VFD cable constructions. Obtain from VFD cable manufacturer.

2.3 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Class 1
   1. Copper conductor, single insulated wire.

2. Insulation type THHN, THHW rated 90°C, 600 V insulation class.
3. Type XHHW-2 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 CONNECTORS, SPLICES, AND TERMINALS

A. Manufacturers:
1. AFC Cable Systems, Inc.
2. Burndy Division of Hubbell Incorporated
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. O-Z/Gedney; EGS Electrical Group LLC.
6. 3M; Electrical Products Division
7. Thomas and Betts Division of ABB
8. 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.

2.5 TERMINATIONS

A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.6 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 with non-metallic ties inside boxes, equipment, and panelboards .
1. Metallic ties not permitted.

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.

1. Lubricants shall be UL listed

G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

H. Provide adequate support for conductors not in raceway. Do not support conductors from ceiling grid or from accessible ceiling support systems.

I. Support conductors in vertical raceways using OZ type "S" cable supports for 600 volt conductors.

J. Support conductors above 600 volts in vertical raceways using OZ type "R" cable supports.

K. Identify conductors and cables according to Section 26 0553 - Electrical Systems Identification.

L. Color code power wiring as follows:

1. 208Y/120 volt, 3-phase, 4 wire: phase A-black, phase B-red, phase C-blue, neutral-white ground conductor-green.
2. 480Y/277 volt, 3-phase, 4 wire: phase A-brown, phase B-orange, phase C-yellow, neutral-gray ground conductor-green.

M. Wiring at Outlets: Install conductor at each outlet, with minimum 12" of slack.

N. Limit conduit fill to a maximum of 9 current-carrying conductors.

O. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under terminal screws.

P. Install VFD input wiring, output wiring and control wiring in their own separate conduit systems.

3.2 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders and Branch Circuits: Solid #12 AWG and smaller; stranded for #10 AWG and larger.

B. Minimum conductor sizes shall be as follows:

1. #12 AWG – Branch circuits of any kind.
2. #14 AWG – Remote control and signal systems, fire alarm system.
3. #10 AWG - Exit light circuits, emergency circuits, security lighting

C. 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.

3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Feeders: Type THWN, XHHW, rated 75°C, or 90°C rated cable sized at 75°C rating for connection to 100% rated devices. Single conductors in raceway.

B. Branch Circuits: Type THHN, XHHW-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.

C. Motor Circuit Branch Wiring Between Motor and VFD: **VFD Cable**

1. Terminate VFD cable using pre-sized and pre-formed termination kits supplied by cable manufacturer. Install per manufacturer's recommendations.

3.4 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Sizing – #14 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. Aluminum and aluminum alloy connectors are not allowed to be used.
   2. 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.
   3. 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.
   4. Joints, taps and splices sizes No. 10 and smaller:
      a. Ideal-Nut Connectors or Scotchlok Spring connectors
   5. Joints, taps and splices sizes No. 8 and larger:
      a. Copper compression connectors
         1) Install with hydraulic compression tool.
   6. Joints, taps and splices sizes larger than No. 1:
      a. Tape with 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.

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. Splices are to be made with compression barrel connector where no taps exist or allowance for future taps is being made.
   4. Where the splice includes provisions for taps, use Burndy insulated Unitap. Locate in pull or junction box sized for all conductors to be spliced and tapped.
   5. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat-shrinkable insulating tubing, or resin-filled insulator.
   6. 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.
   7. Plastic snap-on or piercing type mechanical splice insulators are not allowed.
   8. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Terminals:
   1. All terminals are to be compression type.

2. Train wires to eliminate fanning of stands, crimp with proper tool and die.
3. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
4. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
5. Torque screw termination per manufacturer's recommended values.
6. Terminate motors connections using the following methods:
   a. 300V and below: Use compression-set, insulted eye terminal for screw lug connections or barrel type cable to cable connections.
   b. Above 300V: Use 3M 5300 series insulated motor lead splicing kit.

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. Testing by Testing Agency.

B. Acceptance testing of 600 volt conductors and cables shall be per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

C. Perform electrical acceptance testing on 600-volt feeders serving panelboards, switchboards and secondary voltage service entrance equipment.
   1. Acceptance testing shall include the following:
      a. Verify tightness of accessible bolted connections.
      b. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors.
         1) Applied potential to be 1000 volts DC for one minute
         2) Minimum insulation resistance shall be 50 megohms
         3) Correct deviations between adjacent phases and values below minimum
      c. Perform continuity test to insure correct cable connection.

D. Replace conductors and cables that are found defective, at no expense to Owner.

END OF SECTION

SECTION 26-0526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26 0812 - Power Distribution Acceptance Tests

B. Section 26 0813 - Power Distribution Acceptance Test Tables

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 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.

1.4 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. NETA MTS – Maintenance Testing Specifications

G. NFPA 70 – National Electrical Code

H. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance

I. NFPA 780 – Lightning Protection Systems

J. UL 96 – Lightning Protection Components

K. UL 467 – Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Dimensioned plans showing grounding electrode locations and connections.

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.

D. Closeout Submittals:
   1. Operation and Maintenance Manuals: Include the following:
      a. Instructions for periodic testing and inspection of grounding system.

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 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 Conductor: Bare stranded conductor, size as indicated on drawings.

C. Grounds in concealed, outdoor or in damp/wet locations shall meet IEEE 837 requirements and shall be UL 467 listed.

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. Compression Connectors: Irreversible type.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide Division 27 grounding and bonding infrastructure as specified and shown on plans, including but not exclusive to Communications interconnecting bonding conductors, and bonding jumpers.

1. Division 26 Contractor shall provide and terminate bonding conductors from Division 26-provided infrastructure to the closest Communications Grounding Busbar located in each of the IDF, and EIDF rooms.
2. Division 27 Contractor shall provide and terminate Communications grounding conductors from Division 27-provided equipment to the closest Communications Grounding Busbar located in each of the IDF, and EIDF rooms.

3.2 APPLICATIONS

A. Exposed Bonding Conductors: Install solid conductor for #6 AWG and smaller and stranded conductors for #4 AWG and larger, unless otherwise indicated.

B. Equipment Grounding Conductors: Install solid conductor for #12 AWG and smaller and stranded conductors for #10 AWG and larger. Conductors are to have green insulation for #10 AWG and smaller and identified with green tape at terminations, boxes and splices for sizes #8 AWG and larger.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with feeders and branch circuits. Install for each branch circuit neutral originating from panelboards, lighting circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits
   2. Lighting circuits
   3. Receptacle circuits
   4. Single-phase motor and appliance branch circuits
   5. Three-phase motor and appliance branch circuits
   6. Flexible raceway runs
   7. Armored and metal-clad cable runs

C. Duplex receptacles of any amperage: Install separate jumper between grounding terminal on device and metallic box.

D. Size of equipment grounding conductors for branch circuits: As indicated in NFPA-70, except minimum size shall be #12 AWG.

E. Each branch panel feeder originating at switchboards shall have an identified grounding conductor originating at ground bus in switchboard and terminating at ground bus in panelboard.

F. Size of branch panel feeder originating at switchboards/switchgear: As indicated in NFPA-70, except in no instance smaller than #8 AWG.

G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, Division 27 contractor shall 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. Telecom Grounding Bus: Division 26 contractor shall terminate grounding conductor on grounding bus located in telecom room.
   2. Terminal Cabinets: Division 27 contractor shall bond cabinet grounding terminal to telecom grounding bus.
   3. Cable Tray: Division 27 contractor shall bond cable tray to telecom grounding bus.

H. Install equipment grounding conductor from secondary side of each transformer to grounding electrode system as required for separately derived system.

I. Install grounding conductor to luminaires hanging form conduit swivel hangers.

3.4 SEQUENCING, SCHEDULING

A. Permanently attach equipment grounds prior to energizing equipment.

3.5 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. Grounding conductor is in addition to neutral conductor and in no case shall neutral conductor serve as grounding means.

E. Bond to components of raceway system, such as junction boxes, starter or disconnect switch enclosures, equipment cases, etc.

F. Bond lower end of exhaust ducts, vent stacks, etc., which pass through roof.

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:

I. Bond medical gas piping at point of origin and at each floor of distribution to service entrance grounding bus bar.

J. Make grounding connections on surface that has been cleaned of paint, dirt, oil, etc., so that connections are bare metal to bare metal contact.

K. Make grounding connections tight with UL listed grounding devices, fittings, bushings, etc.

L. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.

M. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.

N. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit: Install green wire grounding conductor with phase conductors in conduit.

1. Conductor to provide ground continuity between equipment or device and conduit-raceway system.

O. Duplex receptacles of any amperage shall be grounding type and shall have separate grounding contact. Install separate jumper between grounding terminal on device and metallic box.

P. Single and duplex receptacles shall have grounded metal mechanically bonded together. Pressure bonding only is not acceptable.

Q. Provide grounding conductor from TV, closed circuit TV system, or radio control equipment locations to grounding electrode system as noted on plans.

R. Communications Grounding Requirements:

1. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.
2. Install Products in accordance with manufacturer's instructions.
    a. Install Compression Connectors with compression, tool and die system, as recommended by manufacturer of connectors.
3. Terminate each grounding conductor on its' own terminal lug.
    a. Multiple conductors on single lug not permitted.

S. All panel boards serving the same individual patient vicinity (procedure, recovery rooms) shall be bonded together in accordance with NEC 517.14 panelboard bonding.

T. Provide patient vicinity grounding and bonding system for all patient rooms. Grounding system shall contain one or more listed grounding and bonding jacks. An equipment bonding jumper not smaller than 10 AWG shall be used to connect the grounding terminal of all grounding type receptacles to the patient equipment grounding point. The bonding conductor shall be permitted to be arranged centrically or looped as required.

END OF SECTION

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SECTION 26-0529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26 0533 – Raceway and Boxes for Electrical Systems

B. Section 26 2200 – Low-Voltage Transformers

C. Section 26 2416.13 – Lighting and Appliance Panelboards

D. Section 26 2416.16 – Distribution Panelboards

E. Section 26 2816 – Enclosed Switches and Circuit Breakers

F. Section 26 2913 – Enclosed Controllers

G. Section 26 5100 – Lighting Systems

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 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. Provide supporting devices as specified and as required for proper support of conduit and electrical equipment.
3. Provide supporting steel, not indicated on structural drawings, that is required for installation of Electrical equipment and materials, including angles, channels, beams, etc. to suspend on floor support equipment.
4. Support for conditions of operation to prevent excess stress and allow for proper expansion and contraction.
5. Conduit clamps, straps, supports, etc., shall be steel or malleable iron. One-hole straps shall be heavy duty type. Straps shall have steel or malleable backing plates when conduit is installed on interior or exterior surface of exterior building wall.
6. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.
7. Conduit hangers for acoustical noise and vibration control.

1.4 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.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Raceway and cable supports.
   3. Support for conductors in vertical raceway.
   4. Structural steel for fabricated supports and restraints.
   5. Mounting, anchoring, and attachment components:
      a. Mechanical-expansion anchors.
      b. Concrete inserts.
      c. Clamps for attachment to structural steel.
      d. Through bolts.
      e. Toggle bolts.
      f. Hanger rods.

B. Shop Drawings: 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. Fabricated metal equipment support assemblies.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”

B. Comply with NFPA 70.

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. 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.
   4. Channels shall not be lighter than 12 ga.

C. Continuous insert channels are not allowed.

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. 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 suite individual conductors or cables supported. Body shall be malleable iron.

G. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
      a. Manufacturers:
         1) Cooper B-Line, Inc.; A division of Cooper Industries
         2) Empire Tool and Manufacturing Co., Inc.
         3) Hilti Inc.
         4) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
         5) MKT Fastening, LLC.

2. Concrete Inserts: Steel, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods:
   a. MSS SP-58; threaded steel, with adjusting and lock nuts; electroplated zinc finish.
   b. Size rods for individual hangers and trapeze supports as required.
7. Wall Anchors:
   a. Flush or shell type, meeting description in Federal Specification FF-S-325, Group VIII, Type 1 for expansion shield anchors.
   b. Select anchors with minimum safety factor of 8.0.

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 gauge.

C. Finish: Electro-galvanized.

D. Manufacturers: Same as in paragraph 2.1.B.3 above.

2.3 CONDUIT HANGERS FOR ACOUSTICAL NOISE AND VIBRATION CONTROL

A. Manufacturers:
   1. Mason Industries, Inc. (Hauppauge, NY), Type HD.
   2. Amber/Booth Co. (Houston, TX), Type BRD-A.
   3. Kinetics Noise Control, Inc. (Dublin, OH), Type RH or FH.
   4. Vibration Eliminator Co., Inc. (Long Island City, NY), Type 3C.
   5. Vibration Mountings & Controls, Inc. (Butler, NJ), Type RHD.

B. HN (hanger neoprene) isolators shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. A pre-compressed glass fiber element may be substituted for the neoprene element.

C. HN isolators shall be selected to achieve 1/10" minimum static deflection under load.

PART 3 EXECUTION

3.1 GENERAL

A. Division 27 Contractor shall provide all Division 27 hangers, supports, and related devices as specified and shown on drawings.

3.2 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
365	3/8	2"
565	1/2	3"
909	5/8	5"

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2" and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

E. Design structural support members and support devices with safety factor of not less than 2.0, unless noted otherwise.

3.3 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.

B. Furnish and install all supports as required to fasten electrical components required for project, including free standing supports required for those items remotely mounted from building structure, catwalks, walkways, etc.

C. Fasten hanger rods, conduit clamps, outlet, junction and pull boxes to building structure using pre-cast insert system, preset inserts, beam clamps, expansion anchors, or spring steel clips (interior metal stud walls only).

D. Raceway Support Methods: In addition to methods described in NECA 1, raceways may be supported by openings through structure members, as permitted in NFPA 70.

E. 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.

F. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. Do not use powder-actuated, plastic, or lead anchor devices.
2. To Wood: Fasten with lag screws or through bolts.
3. To New Concrete: Bolt to concrete inserts.
4. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

5. To Existing Concrete: Expansion anchor fasteners.
6. To Steel: Spring-tension clamps or beam clamps.
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.
    a. Install surface-mounted cabinets and panelboards with minimum of 4 anchors. Provide steel channel supports to stand cabinet 1" off wall.
    b. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud wall.

G. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

H. Do not support raceway by other raceway.

I. Do not support equipment or raceway from metal roof decking or floor decking.

J. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.

K. Do not support loads from bottom chord member of trusses or open web chord.

L. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.

M. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flash and counter flash. Coordinate roof mounting methods with roof system installer to maintain roof warranty provided by roof system installer.

N. Minimize use of concrete anchors and inserts after concrete pour.

O. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.

P. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.

Q. Proposed weld attachments to building structure shall be reviewed by Structural Engineer.
    1. Execution of this work may be assigned to General Trades responsible for building structural steel.
    2. Cost for this work, however, will remain the responsibility of this Contractor.

R. Coordinate hanger and support installation to avoid work of other trades.

S. Conduit shall not be supported by other conduit.

T. Refer to Section 26-0000 - General Electrical Requirements for requirements of personnel injury protection guards for supporting devices.

U. All threaded rods shall be cut within ½” of the nuts of the hanger system.

3.4 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.

3.5 BEAM CLAMPS

A. Provide locknut for hanging rod at clamp.

B. C-clamps are allowed for rod size 1/2" or smaller.

3.6 TRAPEZE SUPPORTS

A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.

3.7 CONCRETE HOUSEKEEPING PADS

A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.

B. Dimensions: 4” high and not less than 4” 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.

3.8 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.
   2. Coat cut edges, welds or damaged finish with galvanized paint.

END OF SECTION

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SECTION 26 0533 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

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 0593 – Electrical Systems Firestopping

F. Section 26 2726 – Wiring Devices

G. Related sections in other Divisions of Work:
   1. Section 27-0528.33 - Raceway and Boxes for Communications Systems

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 DESCRIPTION

A. Section includes raceways, fittings, wireways, outlet boxes, pull and junction boxes, floor boxes, and raceway seals.

1.4 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 C80-6 – Intermediate Metal Conduit-Zinc Coated (IMC)

E. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

F. ETL PVC-001 – Intertek ETL SEMKO High Temerature H^2O PVC Coating Adhesion Test Procedure for 200hrs.

G. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)

H. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

I. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

J. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit

K. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing

L. NFPA 70 – National Electrical Code

M. UL 1 – Flexible Metal Conduit

N. UL 6 – Electrical Rigid Metallic Conduit-Steel

O. UL 360 – Liquid-Tight Flexible Steel Conduit

P. UL 514A – Metallic Outlet Boxes

Q. UL 514B – Conduit, Tubing, and Cable Fittings

R. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings

S. UL 797 – Electrical Metallic Tubing-Steel

T. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings

U. UL 1242 – Electrical Intermediate Metal Conduit-Steel

V. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit

W. BICSI – Telecommunications Reference Manual (TDMM), Latest Edition

X. University of Kentucky - Communications and Network Systems – Telecommunications Standards

1.5 SUBMITTALS

A. Product Data:
   1. Raceways
   2. Fittings
   3. Wireways
   4. Outlet boxes
   5. Pull and junction boxes
   6. 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 2” and larger.
      b. Record actual location and mounting heights of wireways, 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.

1.6 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.

1.7 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.

1.8 WARRANTY

A. Manufacturer shall provide standard one-year 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. Fittings (couplings, conduit bodies, connectors and bushings): NEMA FB 1, UL 514B; steel; threaded; connectors with double locknuts and steel insulating bushings; conduit body cover: stamped steel, with stainless steel screws and neoprene gaskets.

D. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products; O-Z/Gedney; Appleton; Hubbell; Robroy Industries – Perma-Cote.

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 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.D.

2.3 FLEXIBLE METAL CONDUIT (FMC)

A. UL 1; interlocked steel

B. Fittings: NEMA FB I, UL 514B; steel, squeeze-type (screw on are not acceptable)

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. UL 360; interlocked steel, with PVC jacket

B. Fittings: Waterproof, NEMA FB 1, UL 514B; steel

2.5 OPTICAL FIBER CABLE RACEWAY AND FITTINGS

A. Per requirements in Division 27.

2.6 METAL WIREWAYS

A. NEMA 250, UL 870; galvanized sheet metal troughs with hinged or removable cover, Type 1 for indoor and 3R for outdoor, unless otherwise indicated.

B. Size: Length as indicated on drawings.

C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mated with wireways as required for complete system.

D. Wireways Covers: Hinged type or as indicated.

E. Knockouts: Manufacturer's standard.

F. Finish: Manufacturer's standard enamel finish

G. Manufacturers: Cooper B-Line, Hoffman, Square D Co.

2.7 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A; galvanized steel with stamped knockouts.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2" male fixture studs, where required
   2. Concrete Ceiling Boxes: Concrete type
   3. Communications outlet boxes:
      1) Back Box: 5" square, 2-7/8" deep.
   4. Plaster ring: Match depth to provide flush faceplates.

B. Cast-Metal Outlet Boxes: NEMA FB 1, cast aluminum or cast iron (galvanized), Type FD, with gasketed cover and threaded hubs

C. Nonmetallic Outlet Boxes: NEMA OS 2

D. Gangable type boxes are not allowed

E. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds

2.8 PULL AND JUNCTION BOXES

A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel

B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; galvanized, cast iron with ground flange, gasketed cover and stainless steel cover screws

C. Minimum size: 4" square by 2-1/8" deep for use with 1" conduit and smaller; 4-11/16" square by 2-1/8" 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; Hubbell-Weigmann; Hoffman; J&A Sheet Metal Inc. Austin Electrical Enclosures

2.9 B.A.S. HORIZONTAL CONNECTION POINT (HCP) BOXES

A. BID ALTERNATE FOR B.A.S. CABLING ARCHITECTURE.

B. Ceiling enclosure for BAS wiring blocks.

C. Manufacturer: Chatsworth Products A1222-LP or approved equivalent.

2.10 EXPANSION FITTINGS

A. Malleable iron, hot dip galvanized allowing 4" allowing 2" raceway movement.

B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.D.

2.11 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.D.

2.12 RACEWAY SEALING FITTINGS

A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series

B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound

C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound

2.13 CABLE SUPPORTS

A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.D.

2.14 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. Integral Water Stop: Manufacturer: Thunderline Corporation
   1. High density polyethylene (HDPE). Type Century-Line engineered sleeve with end caps.
   2. Steel. Type WS engineered sleeve.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052" or 0.138" thickness and of length to suit application.

2.15 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   2. Pressure Plates: Carbon steel. Include two for each sealing element.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 EXECUTION

3.1 GENERAL

A. Division 27 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including but not exclusive to back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

3.2 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 any through-wall or 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 are available for use.

I. Coordinate locations of Communications boxes, Nurse Call Boxes, B.A.S. Horizontal Connection Points with Owner, B.A.S. vendor, and architect prior to beginning work.

3.3 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.

3.4 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. Cut raceways square using saw or pipecutter.
9. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 1", 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.
10. Use raceway fittings compatible with raceways and suitable for use and environment.
11. Provide bushings on all raceways.
12. Raceways minimum sizes:
    a. Minimum raceway size 3/4", except as noted on drawings.
    b. Minimum home run size: 1", except as noted on drawings.
    c. Minimum size for flexible metal conduit is 3/4" except 1/2" for under-cabinet lights.
    d. Minimum size for liquidtight flexible metal conduit is 3/4".
13. All Communications pathway shall be sized for 40% maximum fill, including 50% future growth.
14. Install empty raceways 2-1/2" and larger with No. 10 galvanized fishwire; install nylon pull cord in raceways smaller than 2-1/2"; leave at least 12" of slack at each end of pull wire.
15. Feed devices on same wall vertically from above or junction box in suspended ceiling.
    a. No horizontal conduit is to be installed between or above junction boxes in walls for any boxes.
    b. Do not install horizontal bends in conduit around corners.
16. Feed devices in exterior or load-bearing walls by horizontal conduit runs. Install horizontal conduit runs from device to device on same wall. Do not install horizontal bends in conduit around corners. Feed devices on same wall vertically from above or junction box in suspended ceiling.
17. 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 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.
18. Identify raceways per requirements in Section 26 0553 – Electrical Systems Identification.
19. Ground raceways per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

20. Flexible Conduit Connections: Use maximum of 72” of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
    a. Use LFMC for connections to vibrating equipment.
    b. Use LFMC in damp or wet locations subject to severe physical damage.
    c. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
    d. Use flexible metallic tubing in plenum spaces.
21. Install stainless steel raceway clamps, mounting hardware, supports, hangers, etc., when located in wet areas.
22. Power and Communications Raceways: Minimum 12” separation when run parallel, cross perpendicular.
23. LB type junction boxes are prohibited in all conduits 1-1/4” or less. Use of LB junction boxes in conduits larger than 1-1/4” require approval by Medical Center Physical Plant division project representative prior to installation.
24. Communications Raceway Requirements:
    a. All Communications raceways shall conform to industry, BICSI, and UK-CNS standards.
    b. All voice, data, video wiring inside rooms shall be protected by metallic conduit or other means such as surface raceway or in-floor troughs.
    c. Bond conduits to cable tray to provide grounding continuity.
    d. No more than an equivalent of 180 degrees of bend, including offsets, are allowed in a conduit run between junction boxes or pull boxes.
    e. No “LBs” are allowed.
    f. Pull boxes shall be provided in conduit runs longer than 100 feet.
    g. Maximum individual conduit run including a pull box shall not exceed 150 feet.
    h. All EMT fittings shall be compression type on conduits less than 2-1/2” in diameter.
    i. Conduits ending at a cable tray shall have plastic bushings and be bonded to the tray.
    j. Conduits terminating within a Communications room shall have plastic bushings and be bonded to the telecommunication grounding bus bar located in that room.
    k. Each horizontal communications conduit shall be home-run to the nearest cable tray. No device to device conduit runs are allowed.
    l. Communications conduit bend radii shall be:
        1) Six (6) times the internal conduit diameter for conduit 2" or less internal diameter.
        2) Ten (10) times the internal conduit diameter for conduit greater than 2" internal diameter.
    m. 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.

B. Wireways:
    1. Install in accordance with manufacturer’s instructions.
    2. Use screws, clips and straps to fasten raceway channel to surfaces.
    3. Mount plumb and level.
    4. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
    5. Supports: Per manufacturer’s recommendations.
    6. Close ends of raceway channel and unused conduit openings.

C. Boxes:
    1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
    2. Install boxes to accommodate minimum Communications cable bend radii and service loop lengths.

3. Install each above-ceiling Communications outlet box for immediate accessibility after all trades are installed.
4. 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.
5. Set outlet boxes parallel to construction and independently attached to same.
6. 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.
   a. All boxes installed in acoustic-rated walls shall be installed with acoustic putty pads.
7. Conduit penetrations plus inset boxes for panels, receptacles, or other functions shall not derate acoustical integrity of acoustical demising partitions. Provide acoustical sealant or resilient fire caulking for penetrations.
8. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
9. 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.
10. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
11. Mount boxes in block walls at block joint nearest to indicated height.
12. 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.
13. When boxes are installed in fire-resistive walls and partitions, provide 24" horizontal separation between boxes on opposite sides of 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. Use FireBlok fire suppression gaskets or fire stop putty pads acceptable to the fire marshal.
    a. Where architectural elevations require an installation that does not allow for required horizontal separation in fire-resistive walls, coordinate installation with Construction Manager.
       1) Boxes installed back-to-back under this condition shall be provided with fire stop putty pads.
14. 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.
15. Install boxes to be permanently accessible. Provide a minimum of 18" clear in front of Communications and Nurse Call pull boxes.
16. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.
17. Adjust box location up to 10' prior to rough-in to accommodate intended purpose.

18. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726 – Wiring Devices.
19. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6” from ceiling access panel or from removable recessed luminaire.
20. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.
21. Large junction boxes may not be used in electrical conductor conduit runs for more than 3 circuits.

D. 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. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
3. 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.
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.

E. Raceway Penetration Seals:
1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Maintenance of Joint Protection" for materials and installation.
3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 0593 – Electrical Systems Firestopping.
4. Roof: Install flashed and hot mopped weatherproof seal, or pitch pan filled and sealed to be weatherproof where raceway penetrates roof membrane. Install weatherhead on raceway stubups penetrating roof.
    a. 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. 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.
7. 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.
8. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.

F. 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, freezers and air handling units, 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.

G. 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. 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.
   5. Cut sleeves to length for mounting flush with both surfaces of walls.
   6. Extend sleeves installed in floors 2” above finished floor level.
   7. Size pipe sleeves to provide 1/4” annular clear space between sleeve and raceway, unless sleeve seal is to be installed.
   8. Communications sleeve requirements:
      a. Extend Communications sleeves installed in floors 6" above finished floor level.
      b. Communications floor sleeves shall be rigid metallic conduit.
      c. Communications floor sleeves shall have threaded bushings on both ends.
      d. Communications floor sleeves shall be bonded to the Telecommunications grounding busbar.

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 in or under concrete slabs
   2. All locations except corrosive atmospheres
   3. Hazardous locations
   4. Locations requiring mechanical protection
   5. Stub up through slabs

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. Electrical Metallic Tubing (EMT) permitted to be installed as follows:
   1. Interior partitions
   2. Above suspended ceilings
   3. In concrete slabs
   4. 6 ft AFF in exposed areas of mechanical equipment rooms
   5. Exposed in areas not subject to damage
   6. Sizes 2” and smaller except as approved

E. 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. Final connections to recessed luminaires in lengths not to exceed 6 ft.
   b. Connection to undercabinet lighting in lengths not to exceed 6 ft.

F. 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
   c. PVC coated LFMC is not allowed in environmental air plenum spaces or air handling equipment.

G. 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

H. Flexible Metallic Tubing (FMT) permitted to be installed as follows:
1. Use liquid tight flexible metallic tubing, not over 6 ft in length, for final connections to:
   a. Electrical equipment located internal to built-up air handling units within plenum spaces.

3.6 CONDUIT COLORS

A. Conduits shall be pre-painted in the following colors for the systems identified:
   a. Life Safety Branch – Yellow
   b. Critical Branch – Orange
   c. Normal Branch – White
   d. Equipment Branch – Silver
   e. Fire Alarm System – Red
   f. Controls – Green
   g. Data/Communications - Blue

3.7 RACEWAY WIRING METHODS

A. Outdoor Locations, Above Grade: Install galvanized rigid steel conduit; install cast metal or nonmetallic outlet boxes with threaded hubs.

B. Wet and Damp Indoor Locations: Install galvanized rigid steel conduit or intermediate metal conduit; threaded conduit fittings; install cast metal or nonmetallic outlet, junction, and pull boxes with threaded hubs. Install flush mounting outlet boxes in finished areas.

C. Concealed and Exposed Dry Locations Not Subject to Damage: Install rigid steel or intermediate metal conduit; install sheet-metal boxes; install flush mounting outlet box in finished areas; install hinged enclosure for large pull boxes.

D. Exposed Subject to Damage: Install galvanized rigid steel conduit; threaded conduit fittings; install cast metal boxes with threaded hubs. Open public spaces such as parking garages and common areas are considered subject to damage.

3.8 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.

3.9 REPAINTING

A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner.

B. Repair damage to paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner.

C. Wireways: 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.

3.10 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.

3.11 CLEANING

A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

3.12 LABELING

A. All labeling shall comply with the published labeling UKPPDMC standard.

B. Stencil systems pull boxes:
   1. Nurse Call as “NURSE CALL”
   2. Communications as “COMM”

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SECTION 26-0533.13 SURFACE RACEWAY SYSTEM

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 26-0553 - Electrical Systems Identification

D. Section 26-2726 - Wiring Devices

E. Related sections in other Divisions of Work:
   1. Section 27-0528.39 - Surface Raceways for Communications Systems
   2. Section 27-0553 - Communications Systems Identification
   3. Section 27-1500 - Communications Horizontal Cabling

1.2 REFERENCE

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

1.3 DESCRIPTION

A. This Section includes surface metallic and nonmetallic raceway system for branch circuits, data network, voice, video and other low-voltage wiring.

B. Surface raceway system shall consist of raceway bases, appropriate fittings and device mounting plates necessary for complete installation.

1.4 REFERENCE STANDARDS

A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting

B. NFPA 70 - National Electrical Code

C. UL 5 - Surface Metal Raceways and Fittings

D. UL 5A - Nonmetallic Surface Raceways and Fittings

E. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.5 SUBMITTALS

A. Product Data: catalog cuts of components.

B. Shop Drawings:
   1. Complete layout, with locations of raceway components.
   2. Grounding, branch circuiting and wiring including locations of service entrances.
   3. Receptacle types, manufacturers, and spacing.
   4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.
   5. Communication faceplate types, manufacturers and labeling.

C. Verify exact color selections of surface raceway with Architect.
   1. Size: As shown on drawings.

D. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Closeout Submittals:
   1. Project Record Documents
      a. Record actual locations of surface raceways with receptacle types, locations and circuits identified.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Obtain all surface raceways from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

B. Comply with manufacturer's written instructions.

1.8 WARRANTY

A. Manufacturer shall provide standard one-year 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. Metallic Raceways:
   1. Mono-Systems
   2. Post Glover
   3. Square D
   4. Wiremold

2.2 FABRICATION

A. UL 5, UL 5A, as applicable.

B. Fabrication:
   1. Aluminum, as noted on drawings.
   2. Suitable for use in dry interior locations only.

3. Two-piece with base and snap-on cover.
4. Size as indicated on plans.
5. Base and cover plate as noted on drawings.
6. Covers with cutouts for device plates as shown on drawings.
7. 6" and 12" long device plates with flange to overlap joint of adjacent cover.

C. Pre-wired Raceways:

1. Wiring devices factory installed, wired, and covers labeled with panel number and circuit number, voltage, phase, and amperes, as identified on drawings, per requirements in Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables and Section 26 2726 - Wiring Devices.
2. Raceway sections with 12" pigtails at feed locations, in 2 ft minimum length and customized to match length shown on drawings.
3. Equivalent distance between receptacles; number of receptacles per length of raceway as shown on drawings.
4. Factory installed, NFPA 70 sized, grounding conductors, per requirements in Section 26 0526 - Grounding and Bonding for Electrical Systems.
5. Raceway covers with hole-cut provisions for communication outlets.
6. Wiring devices on top and communication outlets on bottom.

D. Material:

1. Steel Raceways: galvanized steel, minimum thickness 0.040".
2. Aluminum Raceways: alloy 6063-T5 extruded aluminum, minimum thickness 0.060".
3. Nonmetallic Raceways: nonflammable self-extinguishing, tested to UL94, V-0.
4. Fittings: same material and metal thickness as linear raceway components.

E. Finish:

1. Aluminum Raceways: Satin, No. 204 clear anodized 0.004"inch thick, Class R1 Mil-Spec.
2. Fittings: color to match linear raceway components.

F. Accessories:

1. Fittings: available as standard accessories, including but not limited to external corner units, internal corner units, flat units, blank end units, internal and external elbows, coupling for joining raceway sections, and device mounting brackets and plates.
2. Wire Clips: one for every 2 linear ft of indicated raceway configuration.
3. Corner elbows and tee fittings, to maintain 2" minimum cable bend radius that meets requirements for Communications pathways and specifications for fiber optic, coaxial, and high-performance twisted-pair cabling.
4. Device Mounting Brackets and Plates: plastic device mounting brackets and trim plates allowing installation of indicated wiring devices, and Communications outlets horizontally in raceways; trim cover sized to overlap device cut-out in raceway, concealing seams; finished to match linear raceway components; plastic compatible with UL 94; brackets and plates, to match raceway width, and with device mounting holes.

G. Communications surface raceway requirements:

1. Surface-mount raceways shall:
   a. Be sized to allow for installation of Category 6A F/UTP cables in quantities specified on drawings, plus 50% future cable quantity growth..
   b. Include exposed jack dimensions when calculating raceway capacity.
   c. Allow for minimum depth of 2.7” for jack and bend radius of Category 6A F/UTP cables within the surface raceway cavity.

d. Allow for passing Division 27 cables within surface raceway cavity.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including but not exclusive to back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

3.2 COORDINATION

A. Coordinate cover plate openings with wiring devices contained within.

B. Coordinate cover plate openings with Communications outlets contained within, to provide for one opening for each communication symbol shown on drawings in Division 27. Coordinate device plate sizes (single-gang or two-gang) to accept communication faceplate types specified in Division 27.

C. Verify with manufacturer that 'touch-up' paint kit is available for repainting.

3.3 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before proceeding.

3.4 INSTALLATION

A. Install in accordance with ANSI/NECA 1 and manufacturer's instructions.

B. Coordinate and verify all raceway mounting heights with architectural elevations.

C. Install flathead screws, clips and straps to fasten surface raceways to substrates, ensuring they are permanently and mechanically anchored. Mount plumb and level. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

D. Install wiring devices of type, quantity and spacing as indicated on drawings.
   1. Communications outlets shall be installed by the Division 27 contractor.

E. Mount raceways on wall and casework parallel to or at right angles to structure and casework.

F. Feed raceways mounted on walls and casework from backbox through wall box connector. Determine point of feed in field and complete wiring connections. Raceway feed for communications shall be sized and installed to provide cable capacity and meet bend radius requirements without damaging cable.

G. Maintain ground continuity throughout entire raceway length per requirements in Section 26 0526 - Grounding and Bonding for Electrical Systems.

H. Do not cut in field prewired raceways.

I. Install appropriate backbox extension rings where raceway is mounted to steel slotted channel or by some other method, stood off from wall.

J. Raceway receptacle faceplates shall be labeled with adhesive labels with 1/4" high lettering, per requirements in Section 26 0553 - Electrical Systems Identification, indicating receptacles voltage, phase, and amperage

(i.e., 120V, 1-phase, 20A) at top of receptacle, and panel and circuit designation (i.e., NLP-D2-2/12) at bottom of receptacle, in accordance with requirements in Section 26 0553 - Electrical Systems Identification.

K. Reinforce each cover section for every 30A receptacle in raceway with two 4-40 Phillips counter-sunk steel screws attached to enclosure near top and bottom of receptacle.

L. Identify communication outlets per requirements in Division 27.

M. Raceway base shall be secured using screws. Securing with double-sided adhesive is not acceptable.

3.5 FIELD QUALITY CONTROL

A. Inspect surface raceways for physical damage and proper alignment.

B. Inspect components, wiring, connections, installation, and grounding.

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 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 26-0553 ELECTRICAL SYSTEMS IDENTIFICATION

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 26-0533 - Raceway and Boxes for Electrical Systems

D. Section 26-2416.13 - Lighting and Appliance Panelboards

E. Section 26-2416.16 - Distribution Panelboards

F. Section 26-2726 - Wiring Devices

G. Section 26-2913 - Enclosed Controllers

1.2 REFERENCE

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

1.3 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

PART 2 PRODUCTS

2.1 IDENTIFYING DEVICES

A. Stencil Paint:
   1. Oil-based, alkyd enamel, black unless otherwise noted.

B. Marker System:
   1. Acceptable Manufacturers: Brady USA, Ideal, Marking Services Inc. (MSI), Seton.
   2. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant 2" wide; compounded for outdoor use.
   3. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather-and chemical-resistant coating and matching wraparound adhesive tape for securing ends.
   4. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment.
   5. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies.
   6. 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.

C. Laminated Plastic Nameplates:
   1. ASTM D 709, Type I, cellulose, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore.
   2. Nameplates shall have 1/2" high lettering, except where space is limited letters may be 1/4" high.

3. Face of nameplate to be black and letters to be white, except emergency power equipment nameplates are to have white face with red letters.
4. Fasteners shall be small metal screws, pop rivets or contact-type with permanent adhesive.

PART 3 EXECUTION

3.1 GENERAL

A. After painting is completed, identify equipment as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.

3.2 IDENTIFICATION

A. Nameplates shall be securely attached to non-concealed junction box covers of the following:
   1. Telephone Distribution System
   2. Electrical Distribution System
   3. Fire Alarm System
   4. Intrusion Alarm System
   5. Clock System
   6. Sound System
   7. Public Address System
   8. Nurses Call System
   9. Closed Circuit Television System

B. Engraved plastic nameplates shall be securely attached to:
   1. Panelboards
   2. Motor Starters
   3. Each separately mounted circuit breaker or disconnect switch
   4. Each new device in Distribution system.

C. 4" round, 4" square and 4-11/16" junction boxes concealed above ceilings may be identified with neat lettering on cover with permanent type black marking pen.

D. Nameplates shall identify equipment or load controlled or function and shall be same as indicated on contract documents. Voltages shall be shown on panelboard nameplates.

E. Motor starter nameplates shall include motor designation and horsepower.

F. Group conductors as to circuits and arrange in neat manner in pull boxes, cabinets and panelboards. Group, bind together with nylon ties and identify conductors as to feeder or branch circuit. Phase identification shall be consistent throughout system.

G. Identify each conductor of all systems at each panel, pull box and at each outlet with permanently attached, wrap around, adhesive markers.

H. Identification of junction boxes and conductors shall include panelboard, switchboard or motor control center, circuit number, phase, control circuit number or other appropriate number or letter that will expedite future tracing and trouble shooting.

I. Label inside of receptacle back box with panelboard and circuit number serving the receptacle. Labeling shall be done legibly in permanent black Sharpie magic market.

J. Conduit, boxes and enclosures for emergency and fire alarm circuits shall be marked so as to be readily identified as part of emergency system.

K. Labeling configuration shown on electrical plans intended for construction purposes. Labeling of electrical distribution equipment once installed must coincide with the University of Kentucky standard naming and labeling convention.

L. All labeling shall comply with published UKPPDMC labeling standards.

3.3 ACCESS PANEL IDENTIFICATION

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

END OF SECTION

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SECTION 26-0573 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26-0000 - General Electrical Requirements

B. Section 26-2813 - Fuses

C. Section 26-2816 - Enclosed Switches and Circuit Breakers

1.2 REFERENCE

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

1.3 DESCRIPTION OF WORK

A. Furnish short circuit and protective device coordination studies.

B. Perform study using "SKM System Analysis, Inc.," Power Tools Electrical Engineering Software.

1.4 REFERENCE STANDARDS

A. IEEE 141 - Recommended Practice for Electric Power Distribution and coordination of Industrial and Commercial Power Systems.

B. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings.

C. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

D. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis.

E. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

F. ANSI C37.13 - Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

G. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

1.5 SUBMITTALS

A. Preliminary short-circuit and protective device coordination studies shall be submitted with distribution equipment shop drawings.

1. Upon completion of preliminary short circuit study, it shall be the contractor’s responsibility to verify that all electrical distribution system equipment submittals are fully coordinated with the results of the preliminary study. Final approval of all electrical distribution equipment will not be given until this preliminary short circuit study has been reviewed by AEI along with the equipment submittals.
2. The short circuit study for new work shall incorporate all of the base building electrical distribution equipment data and include them in the final report.

B. Final short-circuit and protective device coordination studies shall be submitted after equipment is installed but before it is energized.

C. Final report.

1.6 QUALIFICATIONS

A. Short circuit and coordination studies shall be conducted under the supervision and approval of Registered Professional Electrical Engineer.

PART 2 PRODUCTS

2.1 (Not applicable)

PART 3 EXECUTION

3.1 SHORT CIRCUIT STUDY

A. Use typical conductor impedances.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide:
1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram
4. Source impedance data, including utility system and motor fault contribution characteristics
5. Typical calculations
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations

D. Calculate short circuit momentary and interrupting duties for 3-phase bolted fault at:
1. Utility's supply termination point
2. Incoming switchgear.
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Branch circuit panelboards, if above 10,000 AIC

E. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Time-current curves shall be displayed on log-log scale paper.

B. Include on each curve sheet a title and legend, identifying portion of the system covered.

C. Identify device by manufacturer type, function and tap, time delay, and instantaneous settings recommended.

D. Plot characteristics where applicable:
1. Electric utility's protective device

2. Medium voltage equipment relays
3. Medium and low voltage fuses including minimum melt, total clearing and damage bands.
4. Low voltage circuit breaker trip devices
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
6. Conductor damage curves
7. Ground fault protective devices
8. Motor starting characteristics and motor damage points
9. Generator short circuit decrement curve and generator damage point

3.3 FINAL REPORTS

A. One Line Diagram

B. Input Data:
   1. Cable and conduit materials
   2. Transformers
   3. Bus ducts
   4. Reactors
   5. Circuit resistance and reactive values

C. Short Circuit Data:
   1. Source fault impedance
   2. Generator contributions
   3. X to R ratios
   4. Asymmetry factors
   5. Motor contributions
   6. Short circuit kVA
   7. Symmetrical and asymmetrical fault currents

D. Recommended Protective Device Settings:
   1. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground)
      b. Adjustable time-current characteristic
      c. Adjustable instantaneous pickup
   2. Phase and Ground Relays:
      a. Current setting
      b. Time setting
      c. Instantaneous setting
      d. Specialty non-overcurrent device settings
   3. Fuses:
      a. Types
      b. Rating

3.4 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

END OF SECTION

SECTION 26-0593 ELECTRICAL SYSTEMS FIRESTOPPING

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26-0000 - General Electrical Requirements

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

C. Section 26-0536 - Cable Trays for Electrical Systems

D. Section 26-0593 - Electrical System Firestopping

1.2 REFERENCE

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

1.3 DESCRIPTION

A. Furnish and install work under this Section including the following:

1. Penetrations through fire-resistance-rated floor, roof, walls and partitions including openings containing conduits, cables, cable bundles, cable tray and other penetrating items.
2. Firestopping systems and installation shall provide fire rating equal to that of construction being penetrated.
3. Proposed firestop materials and methods shall conform to applicable code requirements of authority having jurisdiction.

1.4 REFERENCE STANDARDS

A. UL 1479 - Fire Tests For Through-Penetration Firestops

B. UL 2079 - Tests For Fire Resistance of Building Joint Systems

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed firestopping systems that are similar in material, design and extent to that indicated for this Project and that have performed successfully.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc, or Rectorseal Corp.

B. Pyrophobic Systems, Ltd - Intumescent Technologies FireBlok fire suppression gasket for use in 4” X 4” X 2-1/8” boxes.

2.2 MATERIALS

A. Use only firestop products that have been UL 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. Materials shall not contain flammable solvents.

C. Use removable pillow type fire stop material with cable tray.

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 PROJECT CONDITIONS

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

B. Ventilate firestopping per manufacturers' instructions by natural means or, where this is inadequate, forced air circulation.

DELIVERY AND HANDLING

C. 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.

D. Handle with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

3.3 PREPARATION

A. Clean out openings immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer.

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.

3.4 INSTALLATION

A. Comply with manufacturer's installation instructions and drawings.

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

C. Avoid multiple penetrations of common fire barrier opening. When possible, seal each penetration in accordance with project details.

3.5 SEQUENCING AND SCHEDULING

A. Do not cover up firestopping installations that will become concealed behind other construction until authorities having jurisdiction, if required, have examined each installation.

B. Where deficiencies are found, repair or replace firestopping so that it complies with requirements.

3.6 CLEANING

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

END OF SECTION

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SECTION 260800 - COMMISSIONING OF ELECTRICAL

Release: 09/2017

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to Section 019100.

C. Commissioning requires the participation of the Division 26 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019100. Division 26 Contractor shall be familiar with all parts of Section 019100 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of Section 019100.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Commissioning Plan (Cx Plan)
2. Section 019100 - Commissioning
3. Section 220800 - Commissioning of Plumbing
4. Section 230800 - Commissioning of HVAC
5. Section 270800 - Commissioning of Communications

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Test equipment required for NETA Acceptance Testing.
2. Light meter.
3. Digital multimeter capable of measuring voltage (AC/DC), current, and resistance.
4. Power quality and energy analyzer capable of capturing waveform (3 phase) and data recording.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 019100 for additional Division 26 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of Section 019100.

END OF SECTION - 260800

SECTION 26-0812 POWER DISTRIBUTION ACCEPTANCE TESTS

PART 1 GENERAL

1.1 RELATED WORK

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

B. Section 26 0813 – Power Distribution Acceptance Test Tables

C. Section 26 2200 – Low-Voltage Transformers

D. Section 26 2816 – Enclosed Switches and Circuit Breakers

E. Section 26 2913 – Enclosed Controllers

1.2 REFERENCE

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

1.3 SCOPE OF SERVICES

A. It is the purpose of these specifications to assure 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.

B. Tests and inspections shall determine suitability for energization.

C. Equipment to be tested and inspected:

1. Overcurrent protective device operation and settings
2. Panelboard feeders

1.4 APPLICABLE CODES, STANDARDS AND REFERENCES

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 C57, Distribution, Power, and Regulating Transformers

D. ANSI/IEEE C62, Surge Protection

E. ANSI/IEEE Std. 81. IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

F. ANSI/IEEE Std. 141. IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)

G. ANSI/IEEE Std. 142. IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)

H. ANSI/IEEE Std. 241. IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book)

I. ANSI/IEEE Std. 242. IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)

J. ANSI/IEEE Std. 399. IEEE Recommended Practice for Power Systems Analysis (Brown Book)

K. ANSI/IEEE Std. 446. IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (Orange Book)

L. ANSI/IEEE Std. 493. IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (Gold Book)

M. ANSI/IEEE Std. 1100. IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (Emerald Book)

N. NETA - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

O. NEMA AB4: Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications

P. NEMA MG1: Motors and Generators

Q. NFPA 70: National Electrical Code

R. NFPA 70E: Electrical Safety Requirements for Employee Workplaces

S. NFPA 101: Life Safety Code

T. NFPA 110: Emergency and Standby Power Systems

U. OSHA - Part 1910: Subpart S - 1910.308

1.5 QUALIFICATIONS OF TESTING AGENCY

A. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.

B. Testing laboratory shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories, Title 29, part 1907.

C. Lead, on site technical person shall be currently certified by the National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

D. Testing firm shall use technicians who are regularly employed by firm for testing services.

E. Testing firm shall submit proof of above qualifications with bid documents when requested.

1.6 DIVISION OF RESPONSIBILITIES

A. Contractor shall provide test power required when testing equipment before service energization and coordinate availability of test power with Trade Contractor after service energization. This Contractor shall provide any specialized test power.

B. Coordinate with Construction Manager/Owner/Engineer regarding testing schedule and availability of equipment ready for testing.

C. Project electrical engineer shall supply to testing firm prior to commencement of testing:

1. Short-circuit analysis and coordination study
2. Protective device setting sheet

3. Complete set of electrical plans and specifications
4. Pertinent change orders

D. Notify Owner and Engineer 10 days before testing.

E. Prepare test results with comparison to industry and manufacturer's values and tolerances.

F. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with contract documents.

G. Assure suitability for energization.

H. Any system, material, or workmanship, which is found defective on the basis of acceptance tests, shall be reported.

I. Recommendations for acceptance or rejection shall be given upon consultation of Engineer and prior to energizing equipment.

J. Testing firm shall maintain written record of tests and shall assemble and certify final test report.

K. Safety and Precautions:

1. Safety practices shall include the following requirements:
   a. Applicable State and Local safety operating procedures.
   b. Owner's safety practices.
2. All tests shall be performed with apparatus de-energized unless otherwise noted.

L. Items to be tested and inspected as follows:

1. 600-volt conductors and cables
2. Dry type transformers
3. Low-voltage insulated-case/molded-case circuit breakers
4. Low-voltage disconnect switches
5. Thermographic survey

1.7 TEST EQUIPMENT

A. Test Instrument Calibration:

1. Testing firm shall have calibration program that assures test instruments are maintained within rated accuracy.
2. Instruments shall be calibrated in accordance with the following frequency schedule:
   a. Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
   b. Laboratory instruments: 12 months
   c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.
3. Dated calibration labels shall be visible on test equipment.
4. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
5. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
6. Calibrating standard shall be of higher accuracy than instrument tested.

1.8 SUBMITTALS

A. Test Reports:

1. Testing firm shall provide 3 copies of complete testing report.
2. Provide owner with 1 hard copy and 1 electronic copy of complete testing report.
3. Test report shall include the following:
    a. Summary of project
    b. Description of equipment tested
    c. Equipment used to conduct the test
    d. Description of test
    e. Test results, as compared to manufacturers or industry accepted standards and tolerances
    f. Conclusion and recommendation
    g. Signature of responsible test organization authority
4. Provide list of equipment used to perform tests. Identify the following:
    a. Type
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Date of last calibration
    f. Documentation of calibration leading to NIST standards

B. Completed report to Engineer no later than 30 days after completion of testing unless otherwise directed.

PART 2 PRODUCTS

2.1 Not Applicable to this Section.

PART 3 INSPECTION AND TEST PROCEDURES

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. Dry Type Transformers:
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) Perform thermographic survey of bolted electrical connections, in accordance with paragraph "Thermographic Survey."
7) 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.

3. 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.

4. 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%.

5. 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 1°C at 30°C.
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 1°C to 3°C indicate possible deficiency and warrant investigation.

2) Temperature differences of 4°C to 15°C indicate deficiency; repair as time permits.

3) Temperature differences of 16°C and above indicate major deficiency; repair immediately.

4) Suggested actions based on temperature rise can be found in Table 18.

END OF SECTION

SECTION 26-0813 POWER DISTRIBUTION ACCEPTANCE TESTS TABLES – TEST TABLES 1-12

TABLE 1
Insulation Resistance Test Values
Electrical Apparatus And Systems

Voltage Rating	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance In Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

See Table 14 for temperature correction factors.

TABLE 2
Switchgear Low-Frequency Withstand Test Voltages

Type of Switchgear	Rated kV	Maximum Test Voltage kV	
		AC	DC
Low-Voltage Power Circuit Breaker Switchgear	.254	1.6	2.3
	.508	1.6	2.3
	.635	1.6	2.3
MC (Metal-Clad Switchgear)	4.76	14.0	20.0
	8.25	27.0	37.0
	15.0	27.0	37.0
	27.0	45.0	+
	38.0	60.0	+
SC (Station-Type Cubicle Switchgear)	15.5	37.0	+
	38.0	60.0	+
	72.5	*120*.0	+
MEI (Metal-Enclosed Interrupter Switchgear)	4.76	14.0	20.0
	8.25	19.0	27.0
	15.0	27.0	37.0
	15.5	37.0	52.0
	25.8	45.0	+
	38.0	60.0	+

Derived from ANSI/IEEE C37.20.2-1993, Paragraph 5.5, *Metal-Clad and Station-Type Cubicle Switchgear* and C37.20.3-1993, Paragraph 5.5, *Metal-Enclosed Interrupter Switchgear*, and includes 0.75 multiplier with fraction rounded down.

The column headed "DC, Maximum Test Voltage kV" is given as a reference only for those using DC tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a DC withstand test on AC equipment or that a DC withstand test represents an acceptable alternative to the low-frequency withstand tests specified in this specification, either for design tests, production tests, conformance tests, or field tests. When making DC tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute.

Because of the variable voltage distribution encountered when making DC withstand tests, the manufacturer should be contacted for recommendations before applying DC withstand tests to the switchgear. Voltage transformers above 34.5kV should be disconnected when testing with DC. Refer to ANSI/IEEE C57-13-1993 (*IEEE Standard Requirements for Instrument Transformers*) paragraph 8.8.2.
+ Consult Manufacturer

TABLE 3
Recommended Dissipation Factor/Power Factor at 20°C
Liquid Filled Transformers, Regulators, and Reactors
Acceptance Test Values

Oil, Silicone, and Less-Flammable Hydrocarbon Maximum Value (Percent)	
New Power Transformers and Reactors	0.5%
New Distribution Transformers and Regulators	1.0%
Remanufactured Power Transformers and Reactors	1.0%
Remanufactured Distribution Transformers and Regulators	1.5%

TABLE 4
Insulating Fluid Limits

Table 4.1 **Test Limits for New Insulating Oil Received in New Equipment**		
Mineral Oil		
Test	**ASTM Method**	**# 69 kV and Below**
Dielectric breakdown, kV minimum	D877	30
Dielectric breakdown, kV minimum @ 1 mm(0.04”) gap	D1816	25
Dielectric breakdown, kV minimum @ 2 mm(0.08”) gap	D1816	45
Interfacial tension mN/m minimum	D971 or D2285	38
Neutralization number, mg KOH/g maximum	D974	0.015
Water content, (ppm) maximum	D1533	20
Power factor at 25°C, %	D924	0.05
Power factor at 100°C, %	D924	0.40
Color	D1500	1.0
Visual condition	D1524	Bright and clear

ANSI/IEEE C57.106-2002, *Guide for Acceptance and Maintenance of Insulating Oil in Equipment,* Tables 1, 2, and 3.

Table 4.2 **Test Limits for Silicone Insulating Liquid in New Transformers**		
Test	**ASTM Method**	**Acceptable Values**
Dielectric breakdown, kV minimum	D877	30
Visual	D2129	clear, free of particles
Water content, (ppm) maximum	D1533	50
Dissipation/power factor, 60 Hz, % max. @ 25°C	D924	0.1
Viscosity, cSt @ 25°C	D445	47.5 – 52.5
Fire point, °C, minimum	D92	340
Neutralization number, mg KOH/g max.	D974	0.01

ANSI/IEEE C57.111-1989 (R1995), *Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers,* Table 2.

TABLE 4 (CONT.)
Insulating Fluid Limits

Table 4.3 **Typical Values for Less-Flammable Hydrocarbon Insulating Liquid** **Received in New Equipment**				
ASTM Method	**Test**	**Results**		
		Minimum		**Maximum**
D1816	Dielectric breakdown voltage for 2 mm(0.08”) gap, kV	40	34.5 kV class and below	---
		60	Desirable	
D1816	Dielectric breakdown voltage for 1 mm(0.04”) gap, kV	20	34.5 kV class and below	---
		30	Desirable	
D974	Neutralization number, mg KOH/g	----		0.03
D877	Dielectric breakdown voltage kV	30		----
D924	AC loss characteristic (dissipation factor), % 25°C 100°C	 ---- ----		 0.1 1
D1533B	Water content, (ppm)	----		25
D1524	Condition-visual	Clear		
D92	Flash point (°C)	275		----
D92	Fire point (°C)	300[a]		----
D971	Interfacial tension, mN/m, 25°C	38		----
D445	Kinematic viscosity, mm^2/s. (cSt), 40°C	1.0×10^2(100)		1.3×10^2(130)
D1500	Color	----		L2.5

ANSI/IEEE C57.121-1998, *IEEE Guide for Acceptance and Maintenance of Less-Flammable Hydrocarbon Fluid in Transformers,* Table 3.

The test limits shown in this table apply to less-flammable hydrocarbon fluids as a class. Specific typical values for each brand of fluid should be obtained from each fluid manufacturer.

a. If the purpose of the HMWH installation is to comply with the NFPA 70 *National Electrical Code*, this value is the minimum for compliance with NEC Article 450.23.

TABLE 5

Transformer Insulation-Resistance
Acceptance Test Voltage and Minimum Results

Transformer Coil Rating Type in Volts	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance in Megohms	
		Liquid Filled	Dry
0 - 600	1000	100	500
601 - 5000	2500	1000	5000
5001 - 15000	5000	5000	25000

See Table 14 for Temperature Correction Factors.
NOTE: Since insulation resistance depends on insulation rating (kV) and winding capacity (kVA), values obtained should be compared to manufacturer's test data.

TABLE 6
Medium-Voltage Cables
Acceptance Test Values

Table 6.1
DC Test Voltages

Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	Nominal Insulation Thickness mils (mm)		Maximum DC Field Test Voltages, kV During/After Installation	
		100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5	8-1000 (8.4-507)	90 (2.29)	115 (2.92)	28	36
	Above 1000 (507)	140 (3.56)	140 (3.56)	28	36
8	6-1000 (13.3-507)	115 (2.92)	140 (3.56)	36	44
	Above 1000 (507)	175 (4.45)	175 (4.45)	36	44
15	2-1000 (33.6-507)	175 (4.45)	220 (5.59)	56	64
	Above 1000 (507)	220 (5.59)	220 (5.59)	56	64
25	1-2000 (42.4-1013)	260 (6.60)	320 (8.13)	80	96
28	1-2000 (42.4-1013)	280 (7.11)	345 (8.76)	84	100
35	1/0-2000 (53.5-1013)	345 (8.76)	420 (10.7)	100	124

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy;* ANSI/ICEA S-94-649-2000, *Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts*; ANSI/ICEA S-97-682-2000, *Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts*; and The Okonite Company, *High-Voltage Proof Testing.*

The DC field test voltages listed above are intended for cable designed in accordance with ICEA specifications. When older cables or other types/classes of cables or accessories are connected to the system, voltages lower than those shown may be necessary. Consult the manufacturers of the cables and/or accessories before applying the test voltage.

TABLE 6 (CONT.)
Medium-Voltage Cables
Acceptance Test Values

Table 6.2
AC Test Voltages

Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	Nominal Insulation Thickness mils (mm)		AC Test Voltage, kV	
		100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5 KV	8-1000	90 (2.29)	115 (2.92)	18	23
	1001-3000	140 (3.56)	140 (3.56)	28	28
8 kV	6-1000	115 (2.92)	140 (3.56)	23	28
	1001-3000	175 (4.45)	175 (4.45)	35	35
15 kV	2-1000	175 (4.45)	220 (5.59)	35	44
	1001-3000	220 (5.59)	220 (5.59)	44	44
25 kV	1-3000	260 (6.60)	320 (8.13)	52	64
28 kV	1-3000	280 (7.11)	345 (8.76)	56	69
35 kV	1/0-3000	345 (8.76)	420 (10.7)	69	84

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy;* ANSI/ICEA S-94-649-2000, *Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts*; ANSI/ICEA S-97-682-2000, *Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts.*

All AC voltages are RMS values.

TABLE 6 (CONT.)
Medium-Voltage Cables
Acceptance Test Values

Table 6.3 **Partial Discharge Requirements** **for Semiconducting Coating and Tape Designs Only**		
Rated Circuit Voltage	**Minimum Partial Discharge Extinction Level, kV**	
Phase-to-Phase Volts	**100% Insulation Level**	**133% Insulation Level**
2001-5000	4	5
5001-8000	6	8
8001-15000	11	15

ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-56 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.*

Table 6.4 **Very Low Frequency Testing Levels** **0.1 Hz Test Voltage (RMS)**	
System Voltage **Phase-to-Phase** **(kV) (RMS)**	**Proof** **Phase-to-Ground** **(kV) (RMS)**
5	10
15	22
25	33
35	47

TABLE 7
Molded-Case Circuit Breakers
Values for Inverse Time Trip Test

(At 300% of Rated Continuous Current of Circuit Breaker)

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.

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 13
SF_6 Gas Tests

Test	Method	Serviceability Limits[a]
Moisture	Hygrometer	Per manufacturer or 200 ppm[b]
SF_6 decomposition byproducts	ASTM D 2685	500 ppm
Air	ASTM D 2685	5000 ppm[c]
Dielectric breakdown Hemispherical contents	0.10" gap at atmospheric pressure	11.5 – 13.5 kV[d]

a. In the absence of consensus standards dealing with SF_6 gas tests, the NETA Standards Review Council suggests the above representative values.
b. According to some manufacturers.
c. Dominelli, N. and Wylie, L., *Analysis of SF_6 Gas as a Diagnostic Technique for GIS*, Electric Power Research Institute, Substation Equipment Diagnostics Conference IV, February 1996.
d. Per Even, F.E., and Mani, G. Sulfur Fluorides, Kirk, *Othmer Encyclopedia of Chemical Technology*, 4th ed., 11,428, 1994.

Reference: IEC 61634 High-Voltage Switchgear and Controlgear – *Use and Handling of Sulfur Hexafluoride (SF_6) in High-Voltage Switchgear and Controlgear*.

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 15 (not used)
High-Potential Test Voltage
Automatic Circuit Reclosers

Nominal Voltage Class, kV	Maximum Voltage, kV	Rated Impulse Withstand Voltage, kV	Maximum Field Test Voltage, kV, AC
14.4	15.0	95	35
14.4	15.5	110	50
24.9	27.0	150	60
34.5	38.0	150	70
46.0	48.3	250	105
69.0	72.5	350	160

Derived from ANSI/IEEE C37.61-1973(R1992), *Standard Guide for the Application, Operation, and Maintenance of Automatic Circuit Reclosers* and from C37.60-1981(R1992), *Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for AC Systems.*

TABLE 16 (not used)
High-Potential Test Voltage
for Acceptance Test of Line Sectionalizers

Nominal Voltage Class, kV	Maximum Voltage, kV	Rated Impulse Withstand Voltage, kV	Maximum Field Test Voltage, kV, AC	DC 15 Minute Withstand (kV)
14.4 (1 ∅)	15.0	95	35	53
14.4 (1 ∅)	15.0	125	42	53
14.4 (3 ∅)	15.5	110	50	53
24.9 (1 ∅)	27.0	125	60	78
34.5 (3 ∅)	38.0	150	70	103

Derived from ANSI/IEEE C37.63-1984(R1990) Table 2 (*Standard Requirements for Overhead, Pad-Mounted, Dry-Vault, and Submersible Automatic Line Sectionalizers of AC Systems*).

NOTE: Values of AC voltage given are dry test one-minute factory test values.

TABLE 17
Dielectric Withstand Test Voltages
Metal-Enclosed Bus

Type of Bus	Rated kV	Maximum Test Voltage, kV	
		AC	DC
Isolated Phase for Generator Leads	24.5	37.0	52.0
	29.5	45.0	--
	34.5	60.0	--
Isolated Phase for Other than Generator Leads	15.5	37.0	52.0
	25.8	45.0	--
	38.0	60.0	--
Nonsegregated Phase	0.635	1.6	2.3
	4.76	14.2	20.0
	15.0	27.0	37.0
	25.8	45.0	63.0
	38.0	60.0	--
Segregated Phase	15.5	37.0	52.0
	25.8	45.0	63.0
	38.0	60.0	--
DC Bus Duct	0.3	1.6	2.3
	0.8	2.7	3.9
	1.2	3.4	4.8
	1.6	4.0	5.7
	3.2	6.6	9.3

Derived from ANSI/IEEE C37.23-1987, Tables 3A, 3B, 3C, 3D, and paragraph 6.4.2. The table includes a 0.75 multiplier with fractions rounded down.

NOTE:

The presence of the column headed “DC” does not imply any requirement for a DC withstand test on AC equipment. This column is given as a reference only for those using DC tests and represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for each class of bus.

Direct current withstand tests are recommended for flexible bus to avoid the loss of insulation life that may result from the dielectric heating that occurs with rated frequency withstand testing.

Because of the variable voltage distribution encountered when making DC withstand tests and variances in leakage currents associated with various insulation systems, the manufacturer should be consulted for recommendations before applying DC withstand tests to this equipment.

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.

TABLE 20
Rated Control Voltages and their Ranges for Circuit Breakers

The maximum voltage is measured at the point of user connection to the circuit breaker [see Notes (9) (10)] with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

Rated Control Voltages and their Ranges for Circuit Breakers					
RATED CONTROL VOLTAGE (8)	**Direct Current Voltage Ranges (1)(2) Volts, DC**		**OPENING FUNCTIONS ALL TYPES**	**RATED CONTROL VOLTAGE (60 Hz)**	**ALTERNATING CURRENT (1)(2)(3)(5) CLOSING, TRIPPING, AND AUXILIARY FUNCTIONS**
	CLOSING AND AUXILIARY FUNCTIONS				
	INDOOR CIRCUIT BREAKERS	**OUTDOOR CIRCUIT BREAKERS**		**SINGLE PHASE**	**SINGLE PHASE**
24	---	---	14-28	120	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 26-0923 LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26-0000 - General Electrical Requirements

B. Section 26-5100 - Interior Lighting

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION OF SYSTEM

A. Provide devices such as wall box dimmers, wall and ceiling mounted occupancy 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.

1.4 REFERENCE STANDARDS

A. UL20 - General Use Snap Switches.

B. UL773A - Non-Industrial Photoelectric Switches for Lighting Control.

C. NEMA WD 7 - Occupancy Motion Sensors.

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

B. Device color samples.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

1. Wall Box Dimmers: Hubbell, Leviton, Lutron, Lightolier (Sunrise and Momentum Series), Prescolite, Unenco
2. Ceiling Sensors:
   a. Ultrasonic Occupancy Sensors: Hubbell, Unenco, Light-O-Matic, MyTech, Novitas Wattstopper (W Series)
   b. Ultrasonic Occupancy Sensors, Switched: Leviton, MyTech, Wattstopper

c. Passive Infrared Occupancy Sensors: Hubbell, Lightolier (Insight Series), MyTech, Tork, Unenco, Wattstopper

d. Dual Technology Occupancy Sensors, PIR and Ultrasonic: Hubbell, MyTech, Unenco, Wattstopper (DT Series)

e. Dual Technology Occupancy Sensors, PIR and Microphonic Switched: Leviton, MyTech, Wattstopper

3. Wall Sensors:

a. Passive Infrared Occupancy Sensors: Leviton, Lightolier (Insight), MyTech, Unenco, Wattstopper

b. Passive Infrared Switched Occupancy Sensors: Hubbell, Lightolier, MyTech, Unenco, Wattstopper

c. Passive Infrared Occupancy Sensors, Dual Level, Switched: Leviton, MyTech, Philips Lighting Controls, Wattstopper,

d. Dual Technology Occupancy Sensors, PIR and Ultrasonic, Switched: Leviton, MyTech, Philips Lighting Controls, Wattstopper

e. Passive Infrared Occupancy Sensors with Ambient Light Sensor: Leviton, Unenco, Wattstopper

4. Power Packs: Light-O-Matic, Lightolier, Leviton, MyTech, Novitas, Tork, Unenco, 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 shown on drawings.

2.3 WALL BOX DIMMERS

A. Dimmers shall:

1. Be ivory colored, unless noted otherwise on drawings.
2. Operate in ambient temperature range of 0°C (32°F) to 40°C (104°F).
3. Be linear slide preset dimmers with power-failure memory.
4. Incorporate separate control of intensity and on/off.
5. 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.
6. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
7. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
8. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.

2.4 OCCUPANCY SENSORS

A. Occupancy Sensor shall:

1. Be ivory colored, unless noted otherwise on drawings.
2. Operate with all lamp and ballast combinations, including magnetic, hybrid, and solid-state ballasts.
3. Have LED to indicate occupant detection.
4. Have adjustable time delays from 30 seconds to 15 minutes and adjustable sensitivity.

B. Ultrasonic circuit shall be:

1. Solid-state crystal controlled.
2. 32 kHz minimum.

C. Ceiling ultrasonic occupancy sensors shall:

1. Have 360° coverage with ceiling height of 12 ft.
2. Be low voltage wired in parallel to common power pack.
3. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.

D. Passive infrared occupancy sensors shall:

1. Incorporate temperature compensated dual element sensor and multi element fresnel lens.
2. Have daylight filter to ensure sensor is insensitive to short-wave length waves emitted by sun.

E. Ceiling passive infrared occupancy sensors shall:

1. Have round, square, or long rectangular coverage patterns to match floor plan layout.
2. Operate within ceiling height of 12 ft.
3. Be low voltage wired in parallel to common power pack.

F. Wall passive infrared occupancy sensors shall:

1. Incorporate all features and performance of passive infrared sensors except for switching.
2. Have switch for either off or auto for normal operation.
3. Be completely self contained to replace standard toggle switches.
   a. Switching mechanism shall be latching air gap relay.
   b. Units may be low voltage devices with sensor power packs similar to ceiling mounted devices.
   c. Power supply shall be internal transformer.
4. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.
5. Have 170° radial spread pattern with minimum of 20 ft axial sensor coverage.
6. Be user adjustable for normal operation.
   a. Sensor shall operate similar to toggle switch, tap on and tap off, with sensor maintaining lighting during detection and time delay lights off.
   b. Alternate operation shall be sensor detection lights on, with sensor maintaining lighting during detection and time delay off.
7. With ambient light sensor shall incorporate all features and performance of passive infrared sensors and ambient light sensors.
   a. Ambient light sensor shall be internal with range of 5 to 300 footcandles.
   b. Ambient light sensing component shall not permit lighting systems to be turned on if enough daylight is present.

G. Dual technology occupancy sensors shall:

1. Include both ultrasonic and passive infrared sensors. Each sensing technology shall have independent sensitivity adjustments and LED to indicate detection.
2. Include both microphonic and passive infrared sensors. Each sensing technology shall have independent sensitivity adjustments and LED to indicate detection.
3. Be designed to be either wall or ceiling mounted as indicated on drawings.

4. Sense motion from both technologies to turn lighting on, but maintained detection from either technology will hold lighting on for set time delay.
5. Be low voltage wired to sensor power packs.
6. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.

H. Sensor power packs shall:

1. Be self-contained transformer relay modules.
2. Have dry contacts capable of switching 20 amp load at either 120VAC or 277VAC.
3. Provide 24VDC output capable of controlling ultrasonic or passive infrared occupancy sensors.

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. Check dimmer preset control for proper operation.

B. Verify dimmers function without producing lamp flicker or audible noise.

C. Verify dimmers function without interference of audio and visual equipment.

D. Adjust occupancy sensors for a 5 minute time delay.

E. Verify proper operation of occupancy sensor switches and by-pass switches.

F. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.

G. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 26-2416.13 LIGHTING AND APPLIANCE PANELBOARDS

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 - Identification for Electrical Systems

F. Section 26-0800 - Commissioning of Electrical Systems

G. Section 26 0812 - Power Distribution Acceptance Tests

H. Section 26-0813 - Testing of Electrical Systems – Test Tables 1-12

1.2 REFERENCE

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

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. This Section includes circuit breaker type lighting and appliance branch circuit panelboards as indicated on drawings and as scheduled.

1.4 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 - Cabinets and Boxes

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

1.5 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Extraneous catalog data must be eliminated.

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, including 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.

1.6 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.

1.7 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.

1.8 WARRANTY

A. Manufacturer shall provide standard 1-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. General Electric

B. Cutler Hammer

C. Siemens

D. Square D

2.2 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. NEMA PB 1, UL 67

B. Fabrication:
   1. Factory assembled
   2. Front hinged to box 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 No. 10 AWG or smaller conductors

C. Panelboard Buses:
   1. 98% conductivity, tin-plated, 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 conductors.
   3. Quick-make, quick-break, with thermal-magnetic trip.
   4. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
   5. Ampere rating as scheduled
   6. Listed as Type SWD for lighting circuits
   7. Listed as Type HACR for air conditioning equipment circuits
   8. Bussing, device mounting hardware, and steel knockouts in dead front where "space" is indicated.
   9. Tandem circuit breakers are not acceptable.
   10. Locks on trip handles where indicated.

11. Ground fault equipment protection (GFEP), rated 30 mA trip, to provide equipment protection for branch circuits feeding electrical heat tracing, where indicated.
12. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated.

E. Cabinet
1. NEMA 250, UL 50.
2. NEMA Type 1, Type 3R (outdoor locations) Type 4X, stainless steel, operating room suites, kitchen areas, enclosure.
3. Front (trim) mounted with door in front with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch. Flush and surface panels as designated on plans.
4. Same height matching trim, where 2 cabinets are mounted adjacent to 1 another in finished areas.
5. Sections of panelboards have the same size, where oversize cabinets are required for 1 section of multi-section panelboard.
6. Boxes and fronts made of code-gauge galvanized steel.
7. Manufacturer's prime coat finish for cabinets mounted in finished areas for field paint to match wall color by others and manufacturer standard gray enamel finish over prime coat for cabinets mounted in unfinished areas.

F. Lighting Control Panels
1. All panels on drawing serving lighting loads on the electrical drawings shall have remote programmable control of circuit breakers in panel as identified on electrical plans.
2. Integral controller.
3. Panels must support open protocol for BACNet over IP communication directly to the UK Facilities Management Tridium System without having to make use of any other devices or gateways.
4. 16 lighting groups of control.
5. Real time astronomical clock.
6. Programmable off warning.
7. Self Diagnostics.
8. Breaker contact status.
9. Event alarm recovery.
10. 16 digital inputs.
11. 3 analog in puts.
12. 16 time-of-day on/off scheduling.
13. Day-of-week repeating schedule.
14. Holidays control override.
15. Leap Year and Daylight Savings Time
16. Enable setting of load shed levels on each breaker.
17. Provide with Ethernet port so that CAT 5 cabling can be used for the data line.
18. Lighting control panels shall be fully configurable and programmable through the UK Tridium System.
19. Panel must have the capability to tie up to 16 low voltage switches with the ability to add additional switch modules as required per electrical drawings.
20. Provide smart breakers in panel as indicated on electrical drawings.

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.

2.4 SURGE PROTECTIVE DEVICES (SPD)

A. As indicated on drawings and as scheduled

B. 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 location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.

B. Instruct manufacturer about 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 size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with amperage equal to incoming feeder.

E. Verify that "touch-up" paint kit is available for repainting.

F. Coordinate painting of cabinets in finished areas with work performed under Division 09 - Finishes.

3.2 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances.

B. Notify Architect/Engineer of 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. Panels with main breakers located at the top of the panel must be fed from above. Panels with main breakers located at the bottom of the panel must be fed from below. The practice of bottom feeding panels with top mounted breakers and top feeding panels with bottom mounted main breakers will not be allowed.

C. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.

D. Panelboard mounting and seismic restraints:
   1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in State of Kentucky, and to comply with Section 26-0548 - Vibration and Seismic Controls for Electrical Systems for seismic criteria.
   2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
   3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by methods described in Section 26-0529 - Hangers and Supports for Electrical Systems
   4. Install two rows of steel slotted channel, with minimum of 4 attachment points, for each panelboard section.

5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.

E. Install top breaker handle a maximum of 6 ft -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 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 clear plastic.

H. Install engraved plastic nameplates under provisions of Section 26-0553 - Identification for Electrical Systems. 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.

I. Label spare circuits as SPARE. Leave spare breakers in OFF position.

J. Room numbers used shall be those used by Owner except as otherwise directed by Architect.

K. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to electrical installation to be outside of dedicated electrical space.

L. Install filler plates in unused spaces.

M. 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.

N. 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.

O. Provide programming for lighting control panels required to incorporate new smart breakers into existing building lighting control programming.

P. The main conductor feeds to all distribution panelboards are to be run so that all distribution panels with main breakers located at the top of the panel shall be fed from above, and all distribution panels with main breakers located at the bottom of the panel shall be fed from below.

Q. Feeders routed through the side gutters to reach the top or bottom main breakers from the opposite end of the panel are not acceptable.

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 Section 26-0812 – Power Distribution Acceptance Tests and Section 26-0813 – Testing of Electrical Systems Tests Tables 1-14.

D. Interpret test results in writing and submit to Engineer.

E. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energization of panelboards.

F. Check panelboards for electrical continuity of circuits and for short-circuits prior to energization.

G. Submit ammeter readings for panelboard feeders indicating normal operating load and phase balance.

H. Balancing Loads: after Substantial Completion, but not more than 2 months after Final Acceptance, conduct load-balancing measurements and make circuit changes as follows:
   1. Perform measurements during period of normal working load as advised by Owner.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. Recheck loads after circuit changes during normal load period. Record load readings before and after changes and submit test records.
   4. Tolerance: difference exceeding 10% between phase loads, within panelboard, is not acceptable.
   5. Reconnect or redistribute circuits and/or circuit breakers to achieve balanced condition. Revise circuit directory to reflect circuiting changes required to balance phase loads.

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.

3.9 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 26 2416.16 DISTRIBUTION PANELBOARDS

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

I. Section 26 4300 – Surge Protective Devices

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 DESCRIPTION

A. Section includes circuit breaker type and fusible switch type power distribution panelboards as shown on drawings and as scheduled.

1.4 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

1.5 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.

B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4” scale electrical room floor plans with panelboard locations.

C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.

D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Report:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of panelboards and record actual circuiting arrangements.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
      c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
      d. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 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.

1.7 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.

1.8 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.

1.9 MAINTENANCE

A. Extra Materials:
   1. Furnish Owner with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler Hammer

D. Siemens

2.2 POWER DISTRIBUTION PANELBOARDS

A. NEMA PB 1, UL 67.

B. Fabrication:
   1. Factory assembled
   2. Individualized breaker dead-front cover door-in-door construction
   3. Incoming feeder lugs: copper conductors
   4. Multiple lugs to match number of conductors per phase
   5. Sub-feed (double) lugs, or feed-through lugs where indicated
   6. Filler plates
   7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

C. Panelboard Buses:

1. 98% conductivity, tin-plated, 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 conductors
3. Quick-make, quick-break, with thermal-magnetic trip and electronic (solid-state microprocessor-based) trip.
4. Equipped with individually insulated, braced, and protected connectors
5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
6. Ampere rating as scheduled
7. Front face flush with each other
8. Large, permanent, individual circuit numbers affixed to each breaker in uniform position
9. Tripped indication clearly shown by breaker handle taking position between “ON” and “OFF.”
10. Listed as Type HACR for air conditioning equipment circuits
11. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
12. For 225A frame size and below: thermal-magnetic trip
13. For 250A frame size and above: electronic trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of all other adjustments.
14. Locks on trip handles where indicated

E. Cabinet
1. NEMA 250, UL 50
2. NEMA Type 1.
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
7. Manufacturer’s standard gray enamel finish over prime coat.

2.3 METERS

A. Provide separate metering compartments with digital meter in accordance with Section 26 2713 - Electrical Metering.

2.4 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

2.5 SURGE PROTECTIVE DEVICES (SPD)

A. Furnished under 26 4300 – Surge Protective Devices

B. As indicated on drawings and as scheduled.

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. The main conductor feeds to all distribution panelboards are to be run so that all distribution panels with main breakers located at the top of the panel shall be fed from above, and all distribution panels with main breakers located at the bottom of the panel shall be fed from below.

M. Feeders routed through the side gutters to reach the top or bottom main breakers from the opposite end of the panel are not acceptable.

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.

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 26-2726 WIRING DEVICES

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

F. Section 26-5100 - Interior Lighting

1.2 REFERENCE

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

1.3 DESCRIPTION OF SYSTEM

A. Provide devices such as switches, receptacles, plates, etc., as shown on drawings and specified.

B. Openings shall be covered with either devices and matching plates, solid blank plates or blank plates with bushed opening.

C. Devices shall be installed plumb, tight to wall surfaces and free of scratches or blemishes.

D. Devices of same type shall be from same manufacturer, unless otherwise noted

E. All receptacles in this project shall be hospital grade.

1.4 REFERENCE STANDARDS

A. Federal Spec. W-C-596F Federal Specifications for Electrical Power Connections

B. Federal Spec. W-S-896-E Federal Specifications for Endurance Testing

C. ANSI NEMA WD-6 Wiring Devices - Dimensional Requirements

D. NEMA WD-1 General Color Requirements for Wiring Devices

E. UL 20 - General Use Snap Switches

F. UL 94V2 - Flammability Testing

G. UL 498 - Attachment Plugs and Receptacles

H. UL 505 - Motor Starter Switches

I. UL 943 - GFCI's 2003

J. UL 1449 - Surge Suppression Devices

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

B. Plate samples.

C. Weatherproof cover plate samples.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Cooper (Arrow Hart, Eagle), Hubbell-Bryant, Leviton, Pass & Seymour.

2.2 FABRICATION AND MANUFACTURER

A. Switches:
   1. Toggle:
      a. 20 Ampere, 120-277 Volt AC, quiet type.
      b. Ivory [Match other devices in area] colored.
      c. Heavy duty toggle
      d. Industrial-Institutional, heavy-duty specification grade
      e. Color-coded face to indicate ampere rating
      f. Heavy gage steel mounting strap
      g. Green Ground terminal
      h. Silver alloy contacts
      i. Motor rated for 1 HP
   2. Keyed:
      a. Meet requirements of Toggle switch
      b. Provide 5 key for each switch
      c. .Provide switches keyed cam lock to building master systems.
   3. Pilot light:
      a. 20 Ampere, 120-277 Volt, AC
      b. Red handle
   4. Interchangeable type:
      a. 20 Ampere, 120-277 Volt, AC
      b. Mullion mounting only
      c. Provide with back box

B. RECEPTACLES
   1. Duplex
      a. Hospital Grade
      b. 2 pole, 3 wire grounding
      c. Separate ground screw
      d. 20 Ampere, 125 Volt, NEMA 5-20R configuration
      e. Ivory colored
      f. Solid 1-piece brass mounting strap with integral ground contacts
      g. RED bodies on Emergency or Standby power

h. Impact resistant thermoplastic face

i. Switched receptacles shall have upper half switched and lower half not switched.

2. Ground Fault Circuit Interrupter (GFCI):
   a. Meet requirements of duplex in addition to:
      1) 20 Ampere, 125 Volt
      2) NEMA 5-20R configuration
      3) Trip level 4 to 6 mAmpere
      4) Trip time .025 seconds nominal
      5) Feed-through design to protect downstream devices on circuit.
      6) Reverse line-load function to prevent GFCI from functioning if wired incorrectly
3. USB Charging:
   a. UL-498 and UL-1310 listed
   b. Two USB 2.1 Amp or 3.0 Amp, 5VDC charging ports in addition to two 120V, 20A NEMA 5-20R outlets in one single gang device.
   c. LED indicator for notification of USB port connection.
   d. Auto-grounding connection type.
4. Locking type
   a. Meet requirements of duplex in addition to:
      1) Back or side wired
      2) Accept up to #8 AWG
      3) Contact spring shall be 1 piece, no rivet construction
      4) Body of device shall be high temperature glass reinforced nylon, suitable for 140°C/284°F continuous use.
      5) Meet UL 175 C.T.I. test
      6) Configuration stamped on the face
      7) 20 and 30 Amp receptacle shall have 1.55" boss diameter
5. Hospital Grade:
   a. Duplex
      1) Meet requirements of duplex in addition to:
         a) UL insertion test
         b) Green dot on face
         c) 20 Ampere, 125 Volt
         d) NEMA 5-20R configuration
         e) High-impact and chemical resistant face
         f) Nickel plated brass strap
   b. Ground Fault Circuit Interrupter (GFCI):
      1) Meet requirements of Hospital Grade Duplex and GFCI in addition to:
         a) 20 Ampere, 125 Volt
         b) NEMA 5-20R configuration

C. WALL PLATES

1. Unbreakable Thermoplastic.
2. Color: Ivory
3. Emergency or Standby power shall be RED with the word "EMERGENCY" engraved or stamped in 1/4", white letters.
4. Locking cover:

a. Hinged steel cover with cylinder loc
b. Motor locking cover with padlock capability

D. Tamper Resistant:
1. Impact resistant thermoplastic
2. Slide cover over receptacle

E. Weatherproof covers:
1. Receptacle:
a. Weatherproof when receptacle is in use
b. Cast aluminum
c. Suitable for type of box to be covered
2. Switch:
a. Cast aluminum lift plate

PART 3 EXECUTION

3.1 INSTALLATION

A. Install devices at heights scheduled, and as indicated on drawings.

B. Install duplex wall receptacles vertically with ground contacts up except where shown otherwise or where space problem occurs.

C. Indicated dimension are to centerline of device.

D. Install lighting switches vertically on latch side of door within 6" of frame edge.

E. Install devices back box 2" above countertop, backsplash or fixed cabinet to bottom of back box.
1. Install devices at same height above 1 countertop, backsplash or fixed cabinet.

F. Verify locations prior to rough-in.

G. Install devices plumb, level with finished surfaces and free from blemishes.

H. Install special purpose receptacles and switches and fixed equipment connections according to shop drawings and rough-in drawings to be furnished by trade(s) providing such equipment.

I. Verify locations prior to rough-in.

J. Identify all receptacles with "Brady" clear vinyl polyester tape with black lettering on front and/or back of plate.
1. Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 Volt, at top of cover plate, and panel and circuit number at bottom of cover plate.
2. Label body of all receptacles with panel and circuit number.

K. Identify switches with "Brady" clear vinyl polyester tape with black lettering on front and back of plate.
1. 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.

L. Lab receptacles to be identified with "Brady" clear vinyl polyester tape with black lettering on front of plate.

1. Label shall indicate receptacle voltage, phase, and amperage for receptacles other than 20A, 120 Volt, at top of cover plate, and panel and circuit number at bottom of cover plate.

END OF SECTION

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SECTION 26-2813 FUSES

PART 1 GENERAL

1.1 RELATED WORK

A. Section 26-2416.16 - Distribution Panelboards

B. Section 26-2816 - Enclosed Switches and Circuit Breakers

C. Section 26-2913 - Enclosed Controllers and Contactors

1.2 REFERENCE

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

1.3 DESCRIPTION

A. This Section includes nonrenewable cartridge fuses, rated 600V and less, for use in low-voltage power distribution system and spare fuse cabinet.

1.4 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

1.5 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.

1.6 QUALITY ASSURANCE

A. Obtain fuses from one source and by single manufacturer.

B. Comply with NFPA 70 for components and installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Bussmann

B. Ferraz Shawmut

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 (Amperes 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 - 100 amps and above

D. 200,000 A RMS Sym withstand rating

E. Copper 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

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 Section 26-2300 - Low-Voltage Switchgear, Section 26-2413 - Switchboards, Section 26-2416.16 - Distribution Panelboards, Section 26-2419 - Motor Control Centers, Section 26-2816 - Enclosed Switches and Circuit Breakers and Section 26-2913 - Enclosed Controllers and Contactors) 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.

3.3 APPLICATION

A. Motor Branch Circuits: Class CC.

B. Other Branch Circuits: Class CC.

3.4 CLEANING

A. Clean fuses and tighten connections prior to energization of equipment.

END OF SECTION

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SECTION 26 2816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

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 26-0800 - Commissioning of Electrical Systems

F. Section 26 0812 - Power Distribution Acceptance Tests

G. Section 26-0813 - Power Distribution Acceptance Test Tables

H. Section 26-2813 - Fuses

1.2 REFERENCE

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

1.3 DESCRIPTION

A. This Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.4 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

1.5 SUBMITTALS

A. Product Data:

1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.

B. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Test Reports:
1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
1. Project Record Documents:
a. Record actual locations of disconnect switches and ratings of installed fuses.
b. Record actual locations and continuous current ratings of enclosed circuit breakers.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 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.

1.7 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.

1.8 WARRANTY

A. Manufacturer shall provide standard 1-year 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. General Electric

B. Cutler-Hammer

C. Siemens.

D. 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

2.3 ENCLOSED CIRCUIT BREAKERS

A. NEMA AB 1, UL 489

B. Enclosed molded-case circuit breakers:
1. Tripped indication clearly shown on breaker handle taking position between "ON" and "OFF".
2. 225A frame size and below: thermal-magnetic trip
3. 250A frame size and above: electronic (solid-state microprocessor-based) trip units interchangeable in field within frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.
4. Locks on trip handles where indicated
5. Molded-case switch in lieu of thermal-magnetic molded-case circuit breaker, where indicated
6. Shunt trip, where indicated

C. Breaker Mechanism:
1. Quick-make, quick-break

D. Ratings:
1. Ampacity as indicated on drawings
2. Listed as Type HACR for air conditioning equipment circuits
3. Listed as Type SWD for lighting circuits

2.4 LUGS

A. Front removable lugs

B. Labeled for 75°C copper 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 No. 10 AWG or smaller conductors

2.5 ACCESSORIES:

A. Solid neutral assembly, where required

B. Equipment ground kit

C. 1 set of normally open (NO) auxiliary contacts, where disconnect switch is installed at 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) Type 4X, stainless steel, kitchen areas, cooling towers, enclosure.

C. Code-gauge galvanized steel

D. Manufacturer's standard gray enamel finish over prime coat

E. Surface-mounted. Flush-mounted, where indicated.

2.7 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 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 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. Do not support disconnect switches and/or enclosed circuit breakers only by raceway.

D. Install top disconnect switch and/or enclosed circuit breaker handle a maximum of 6 ft-6" above finished floor.

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 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.

G. 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 Section 26-0812 – Power Distribution Acceptance Tests and Section 26-0813 - Power Distribution Acceptance Test Tables 1-12

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, as indicated on drawings.

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 26-2913 ENCLOSED CONTROLLERS

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 26-0800 - Commissioning of Electrical Systems

G. Section 26 0812 - Power Distribution Acceptance Tests

H. Section 26-0813 - Power Distribution Acceptance Test Tables

I. Section 26-2813 - Fuses

1.2 REFERENCE

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

1.3 DESCRIPTION

A. This Section includes enclosed manual and magnetic motor controllers and enclosed contactors.

B. All motors shown on the drawings or specified in other Divisions of these Specifications shall be provided with the 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 the 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 volts, three phase and 120 and 208 volt single phase. Circuits are designed for motors with voltage ratings as follows:
   a. Smaller than 1/2 HP motors: 115 volts, single phase.
   b. 1/2 HP motors and larger: 200 and 460 volts, three phase.

1.4 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 Volts Maximum)

D. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC

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 Volts 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

1.5 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 these specifications, and/or by others, prior to this 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.

1.6 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.

1.7 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.

1.8 WARRANTY

A. Manufacturer shall provide standard 1-year warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 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. General Electric

B. Cutler-Hammer

C. Siemens

D. Allen Bradley

E. Square D

2.2 MANUAL MOTOR CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for small motors, with melting alloy type overload relay, red pilot light, (NO) (NC) auxiliary contact, and pushbutton 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 melting alloy type overload relay, (red) 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) 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 volts, 60 hertz.
3. Overload Relays: NEMA ICS 2, solid-state bimetal, one overload relay per phase:
   a. Solid-state type:
      1) Class 10, 20, 30 selectable 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) 1 normally open and 1 normally closed isolated auxiliary contract.
   b. Bimetallic type:
      1) Class 10, 20, 30 inverse-time tripping characteristics
      2) Manual reset
      3) 1 normally open and 1 normally closed isolated auxiliary contract
4. Features:
   a. Auxiliary Contacts: NEMA ICS 2, each normally open and normally closed contacts in addition to seal-in contact.
   b. Pushbuttons: Recessed type.
   c. Pilot Lights NEMA ICS 5: push-to-test LED incandescent neon type.
   d. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.
   e. Control Power Transformers: 120-volt secondary, adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity in each motor controller, but not less than 100VA. Fused primary and secondary, and unfused leg of secondary bonded to enclosure.
   f. Terminals: NEMA ICS 4.
   g. Other accessories detailed or required by drawings.

2.6 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 200 volts motors 25 HP and above.

B. Motor controllers for NEMA rated 460 volts 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 volt 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 GENERAL PURPOSE MAGNETIC CONTACTORS

A. Description: NEMA ICS 2, same as magnetic controllers, except without overload protection.

B. Poles: To match circuit configuration and control function.

C. Configuration: Mechanically held

D. Contact Rating: Match branch circuit overcurrent protection.

2.12 LUGS

A. Labeled for 75°C copper 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 No. 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.

2.13 MOTOR CONTROLLERS AND CONTACTOR ENCLOSURES

A. NEMA 250, NEMA 1CS 6

B. NEMA Type 1, Type 3R (outdoor locations) Type 4X, stainless steel, kitchen areas, Type 4, wet and damp indoor locations enclosure.

C. Code-gauge galvanized steel.

D. Manufacturer’s standard gray enamel finish over prime coat.

E. Surface-mounted. Flush-mounted where indicated.

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. Install motor controllers and contactors anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the state of Kentucky, and to comply with Section 26-0548 - Vibration and Seismic Controls for Electrical Systems for seismic criteria.

2. Fasten motor controllers and contractors firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.

3. 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.

4. Install 2 rows of steel slotted channel, with minimum of 4 attachment points, for each motor controller and contactor.

5. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.

6. Do not support motor controllers and contactors only by raceway.

D. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening valves. Where manufacturer's torque valves are not indicated, use those specified in UL 486A-486B.

E. Install engraved plastic nameplates under provisions of Section 26-0553 - Electrical Systems Identification. Attach nameplate to exterior of each motor controller and contactor, using small corrosion resistant metal screws or rivets. Do not use contact adhesive:

1. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.

F. Connect each motor terminal box to rigid conduit system with maximum 18" of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26-0533 - Raceway and Boxes for Electrical Systems.

G. Check for proper rotation and phase relationship of each motor.

H. Install fuses in fusible switch at job site pre requirements in Section 26-2813 - Fuses.

I. Control Wiring Installation:

1. Install wiring between motor control devices according to Section 26-0519 - Low-Voltage Electrical Power Conductors and Cables.

2. Install motor control wiring in accordance with control wiring diagrams and in raceways where indicated or required by contract drawings.

3. Bundle, train, and support wiring in enclosures.

4. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   a. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   b. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 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 Section 26-0812 – Power Distribution Acceptance Tests and Section 26-0813 - Power Distribution Acceptance Test Tables 1-12.

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 26-5100 INTERIOR LIGHTING

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

F. Section 26-0926 - Lighting Control Systems

1.2 REFERENCE

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

1.3 DESCRIPTION OF WORK

A. Provide luminaires as shown on Contract Drawing 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 or scheduled shall be included.

D. Provide lamps for luminaires as recommended by luminaire manufacturer and as scheduled.

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.

1.4 REFERENCE STANDARDS

A. NECA/IESNA 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems (ANSI)

B. NECD/IESNA 502 - Recommended Practice for Installing Industrial Lighting Systems (ANSI)

C. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility

D. UL 57 - Electrical Luminaires

E. UL 496 - Lampholders

F. UL 773 - Plug-in Photocontrols for use with area lighting

G. UL 924 - Emergency Lighting and Power Equipment

H. UL 935 - Fluorescent Lamp Ballasts

I. UL 1029 - High Intensity Discharge Lamp Ballast

J. UL 1570 - Fluorescent Luminaire

K. UL 1571 - Incandescent Luminaire

L. UL 1572 - High Intensity Discharge Luminaire

M. UL 1598 - Luminaires

1.5 QUALITY ASSURANCE

A. Luminaire and accessory components shall be constructed of materials appropriate for their use.

B. Luminaires, ballasts, lamps and other components shall meet the requirements of all applicable state and municipal energy codes.

C. Provide luminaires listed and labeled 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 and Lighting Consultant. 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.

2. 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.

E. Substitution requests:

1. Will be evaluated prior to bid.

2. Shall follow procedures set forth in this section and in Section 01 2500 - Substitution Procedures.

3. Shall be made not less than 14 days prior to bid date.

4. Shall include the following information:

    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 3-1/2" floppy disk or CD, for use in a recognized computer lighting program.

5. Provide table-top samples and/or mockup of specified luminaire and proposed alternate.

6. Samples shall:

    a. Be fully operable, complete with specified lamp(s) and ready for installation.

    b. Remain available during construction.

7. Electrical Contractor shall be responsible for all costs incurred by substitution request sample and/or mockup production and review.

8. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of 14 weeks. It shall be the sole responsibility of the Electrical Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.

9. 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.

10. 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.

1.6 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.

1.7 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**[/Lighting Designer]** 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. Ballast and Driver schedule indicating manufacturer, type, and catalog number for each luminaire
   7. Ballast cut sheet for each ballast used, referencing luminaire type(s)
   8. Driver cut sheet for each driver used, referencing luminaire type(s)
   9. Lamp schedule indicating manufacturer, type, and catalog number for each luminaire
   10. Lamp cut sheet for each lamp used, referencing luminaire type(s)
   11. Documentation of lamp and ballast or LED and driver compatibility
   12. 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, lamp combinations, ballast/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, ballast or 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, ballast or driver locations/quantity, luminaire joint locations, extension plates for end and corner sections and end plates as applicable.
7. Detailed drawings for custom LED or Fluorescent handrail systems including dimensions, power feed locations, ballast or driver locations/quantity, luminaire joint locations as applicable.
8. 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.
9. Detailed drawings for nonstandard/custom luminaires indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled to a legible size.
10. Detailed drawings for fiber optic systems including scaled plans with cable layout number and type of fiber bundles, illuminator quantity and location, and a complete bill of materials.
11. Drawings for site lighting shall include pole data with wind loading, complete dimensions and finish, pertinent physical characteristics and accessories including mounting details, ballast/driver type and location and any specified control options.
12. Photometric Data: Where indicated on luminaire schedule and Contract Drawings, supply complete photometric data for luminaire, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as follows:
    a. Coefficients of utilization
    b. Luminance table with data presented numerically, showing maximum luminaire luminance at shielding angles. Readings should be taken both crosswise and lengthwise in case of fluorescent luminaire or luminaire with an asymmetric distribution.
    c. Candela distribution data, presented graphically and numerically, in 5° increments (5°, 10°, 15°, etc.). Data developed for up and down quadrants normal, parallel, and at 11-1/2°, 45°, 67-1/2° to lamps if light output is asymmetric.
    d. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above.

13. No variation from the general arrangement and details indicated on drawings shall be made on shop drawings unless required by actual conditions. All variations shall be marked on drawings submitted for approval.

D. Provide luminaires with factory or field finish as directed by Architect/Engineer**[/Lighting Designer]**. 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.

1.8 SAMPLES

A. Upon return of submittals, and prior to release for manufacturing, Contractor shall furnish one sample of each luminaire for which sample requirement is noted.

B. Shipping: Samples shall be complete with specified lamp(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.

1.9 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.

D. Refer to luminaire schedule for additional information on specific luminaires that shall require mock-up prior to final installation.

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. Low Voltage Transformers:
   1. Q-Tran 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 ballasts or 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 lamps to provide the photometric performance documented. Ballasts, low voltage transformers and drivers shall be vented per manufacturer's specifications.

   i. Provide inscription for exit and stairway signs to conform to applicable codes.

   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.

   m. Recessed high intensity discharge luminaires with integral ballasts, installed indoors, shall have UL listed thermal protection integral with ballast. Exceptions are luminaires installed in suspended lay-in, grid type ceilings and which comply with UL suspended ceiling luminaire listing.

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 integral lamp modules with a minimum operating temperature of -20°C.

   f. 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.

   g. Have driver housings easily accessible for ease of maintenance.

   h. Have a maximum operating temperature at LED junction to not exceed 90°C over the expected operating range of the luminaire.

   i. Be RoHS compliant, lead and mercury free.

   j. Have an LED operating frequency of + or – 120 Hz.

   k. Must meet the appropriate Federal Communications Commission (FCC) requirements for FCC 47 CFR 15 (consumer use) and/or FCC 47 CFR Part 18 (industrial use)

   l. Be Class A Sound rated.

m. Be supplied with power supply that complies with IEEE C. 62.41-1991.

n. Operate at 120 or 277 volts, ±10%.

o. Have reverse polarity protected at all hardwired connections and have high voltage protection in the event connections are reversed or shorted during the installation process.

3. Lenses, Reflectors and Diffusers

   a. All lenses or louvers shall be removable, but held so that normal motion will not cause them to drop out.

   b. All glass used in incandescent or 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.

   h. Reflector cones shall not have visible lamp flashing in the cone.

4. Optics and Adjustments

   a. Lamp holders shall be suitable for the indicated lamps and shall be set such that lamps are positioned in optically correct relation to all luminaire components.

   b. Adjustable Angle Luminaire: Luminaires with adjustment beam angle shall contain reliable angle locking devices.

5. Finishes

   a. Provide luminaires with finish as shown in the luminaire schedule. Verify final finish requirements before releasing luminaires for fabrication.

   b. Painted luminaires shall be painted after fabrication or "post painted".

   c. Ferrous parts and supports shall be rust proofed after fabrication.

   d. For weatherproof or vaportight installations, painted finishes of luminaires and accessories shall be weather resistant using proper primers or galvanized and bonderized epoxy, so that entire assembly is completely corrosion resistant for service intended and rated for an outdoor life expectancy of not less than 20 years.

6. Wiring

   a. Luminaires shall be completely wired at the factory and as required by code.

   b. Internal wiring shall contain no splices.

   c. Connections shall be made with insulated "wire nut" type mechanical connectors except that driver connections shall comply with NEC Article 410.

   d. Wire for connections to lamp sockets and lamp auxiliaries shall be minimum #16 AWG luminaire wire.

   e. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.

   f. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.

   g. Provide dual-level switching for luminaires as indicated on luminaire schedule and/or where shown on Contract Drawings. Typically first switch designation controls outboard lamps, and second switch designation controls inboard lamp(s), unless noted otherwise.

   h. Provide wiring for master/ satellite luminaire configuration as indicated on luminaire schedule and/or where shown on Contract Drawings. For single lamp luminaires, provide a two-lamp ballast for two adjacent luminaires. For three-lamp luminaires, provide one two-lamp ballast

for the outboard lamps in each luminaire and an additional two-lamp ballast for the center lamp in each of two adjacent luminaires.

i. Provide wiring for tandem wired luminaires as indicated on luminaire schedule and/or where shown on Contract Drawings. Supply ballasts and wiring to control all top or inboard lamps together and control all bottom or outboard lamps together.

j. Cords shall be fitted with proper strain reliefs and watertight entries where required by application.

k. Provide lamps for all luminaires.

7. Ceiling Coordination

a. Verify type of ceiling construction prior to releasing luminaires for fabrication and delivery.

b. Provide mounting appurtenance, flanges, sloped ceiling adaptors where required.

c. Provide mounting assembly, clips or other mechanical mounting lugs as required for support of luminaires.

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. Have a Lamp Current Crest Factor < 1.5
7. Dimmable LED drivers must be compatible with dimming system(s) provided and control luminaires per luminaire schedule and controls documentation.
8. ETL certified, CBM and UL Listed, high power factor, and meet or exceed NEMA and ANSI Standards.
9. Class A sound rated
10. Equipped with resetting thermal sensitive device.
11. For operation at 60 Hz and voltage as scheduled.
12. Meet or exceed all ANSI or NEMA standards
13. Capable of operating LEDs with less than 5% flicker
14. Be DMX compatible in Color changing LED luminaires.

2.4 TRANSFORMERS

A. Transformers shall be:

1. Sized to compensate for voltage drop over indicated distances
2. Locally fused

B. Transformers shall have line voltage switch within reach.

C. Provide adequate ventilation to meet code and manufacturers requirements.

2.5 LAMPS

A. Provide lamps as noted on Luminaire Schedule.

B. Provide lamps of same type from same manufacturer.

C. Where a specific lamp manufacturer has been indicated in the Luminaire Schedule, lamps shall be supplied from named manufacturer only.

D. Provide all other lamp types and special purpose lamps as noted on Luminaire Schedule.

E. White LED sources shall be:

1. Minimum CRI of 85 unless noted otherwise on Luminaire Schedule
2. Less than **5%** flicker
3. Within 0.004 on the CIE 1976 diagram for color spatial uniformity
4. Within 0.007 on the CIE 1976 diagram for color maintenance over the rated lifetime of the source
5. Binned within a 3-step MacAdam ellipse minimum, or as indicated in Luminaire Schedule
6. Color temperature as noted on Luminaire Schedule
7. Have a published life rating based on the point at which LED sources reach L70 lumen maintenance and tested in accordance with IES LM80-08 Approved Method: Testing Lumen Maintenance of LED light sources and IES TM-21-11: Projecting Long Term Lumen Maintenance of LED Light Sources
8. L70 rated life shall be a minimum of 50,000 hours.
9. LED modules, unless noted otherwise, shall be provided by light fixtures manufacturer and integral to luminaire.

PART 3 EXECUTION

3.1 INSTALLATION

A. Marking:

1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.
2. Lamp/ballast coordination: Luminaires equipped with ballasts or other components requiring use of specific types of lamps shall be plainly marked.
3. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when lamps are in place.

B. Installation of Luminaires:

1. Lamps, 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. Locations
    a. Install luminaires at locations and heights as indicated.
    b. Do not scale electrical drawings for locations of luminaires.
    c. Architectural reflected ceiling plans show locations of luminaires.
    d. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Architect/Engineer prior to installation.
    e. Where luminaires are to be concealed, or surface mounted in highly visible public spaces, a small sampling of luminaires shall be installed, adjusted and aimed for Architect/Engineer's review approval, prior to installing remaining luminaire of same type.
    f. Mount all luminaires so as to maintain full range of motion.
    g. Install luminaires plumb, square, and level with ceilings and walls.
    h. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions.

i. Industrial type luminaires in unfinished areas, which are near obstructions such as ducts and pipes, shall be:
   1) Suspended so that bottom of luminaire is no higher than bottom of obstruction
   2) Located at height of lowest luminaire
   3) Minimum height: 8'-0"
   4) Shall not be located until locations of obstructions are determined.

4. Support
   a. Support surface mount luminaires from building structure.
   b. Metal decking shall not be pierced for luminaire support.
   c. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
   d. Fluorescent troffers shall be held in place by support clips.
   e. Provide plaster frames for recessed luminaires in plaster ceilings.
   f. Recessed luminaires shall be supported with 12 gage wire hangers, 2 per luminaire, at diagonally opposite corners.
   g. Recessed 4 x 4 fluorescent troffers and luminaires over 55 lbs shall be supported with 12 gage 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.
   h. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12-gage wire.
   i. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 gage wire installed from box to structure.
   j. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2', or as recommended by manufacturer.
   k. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.
   l. Rigidly align continuous rows of luminaires.
   m. Luminaire types with remote mounted ballast shall have:
      1) Proper support for ballast weight.
      2) Mounting distance from remote ballast to luminaire per manufacturer's recommendations.
5. Mounting and Enclosures
   a. Install flush mounted luminaires to eliminate light leakage.
   b. For luminaries 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.
6. 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.

C. Lamps:

1. Provide new lamps delivered in original manufacturer’s cartons.

D. Grounding:

1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems".

E. Linear Recessed Lighting Fixture extensions.

1. Where recessed linear lighting fixtures are being installed in continuous runs (i.e. corridors) provide extensions at the end of runs of same construction type as fixtures so that no ceiling gaps are present between fixtures and end of run wells.

3.2 SUBSTANTIAL COMPLETION

A. Quality Control:

1. At Date of Substantial Completion, replace lamps which are not operating properly.
2. Replace any lamps used as worklights during construction phase.
3. Protection wrapping on louvered (parabolic) luminaires shall be removed before installation of furniture, but after finish work is complete.
4. Deliver spare lamps 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. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
5. 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 the direction of Architect/Engineer. These electricians shall be available at times designated by the Architect/Engineer and shall be provided at no extra charge to the owner over

base bid. Contractor shall provide all necessary equipment for luminaire focus including ladders and mechanical lifting systems.

6. Program preset dimming system lighting levels.
7. Exterior poles, bollards, bases and other exterior luminaires shall be painted to match factory color where finish has been damaged.
8. No light leaks shall be permitted at the ceiling line from any visible part or joint.

D. Training

1. Contractor shall provide qualified personnel onsite to provide a minimum of three days of training to Owner's representatives.
2. This training shall cover:
   a. Luminaire use and maintenance.
   b. Architectural lighting system use and maintenance.
   c. Group relamping cycles.

END OF SECTION

SECTION 27 0000 GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCE

A. The Work under this Section and related sections is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.2 DESCRIPTION

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

B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 27 contract documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Division 26 contractor is responsible for all cable tray, conduits, back boxes, and pull boxes required for Division 27 scope.

E. 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.

F. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.

G. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

H. Where architectural features govern location of work, refer to architectural drawings.

I. All work shall be performed in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27-0526 - Grounding and Bonding for Communications Systems
   2. Section 27-0528.29 - Hangers and Supports for Communications Systems
   3. Section 27 0528.33 - Raceway and Boxes for Communications Systems
   4. Section 27-0528.36 - Cable Tray for Communications Systems
   5. Section 27 0537 Communications System Firestopping
   6. Section 27-0553 - Communications Systems Identification
   7. Section 27-1100 - Communications Equipment Room Fittings
   8. Section 27-1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0000 – General Electrical Requirements
   2. Section 26-0529 - Hangers and Supports for Electrical Systems
   3. Section 26 0533 – Raceway and Boxes for Electrical Systems
   4. Section 26-0536 - Cable Trays for Electrical Systems
   5. Section 26 0593 – Electrical Systems Firestopping
   6. Also see individual technical sections identified above.

C. Temporary Services:
   1. Refer to Division 01 - Temporary Facilities and Controls.

D. Continuity of Service:
   1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
   2. When interruption of services is required, persons concerned shall be notified and shall agree upon a time.

E. Cleaning and Repair:
   1. Clean and repair existing materials and equipment that remain or is to be reused.

F. Demolition:
   1. Division 01 - Selective Demolition.
      a. Not applicable to this Division of work.
   2. Division 02 - Building Demolition
      a. Not applicable to this Division of work.
   3. Perform demolition as shown on drawings to accomplish new work (if applicable).
      a. Remove abandoned wiring to source of supply.
         1). Coordinate with Owner for disconnecting wiring at associated cross-connect.
      b. Disconnect outlets and remove devices as shown on drawings.
      c. Remove abandoned outlets if conduit servicing them is abandoned and removed.

d. Provide blank cover for abandoned boxes that are not removed.

e. Disconnect communications systems in walls, floors, and ceilings scheduled for removal.

4. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on Owner or other contractors.

5. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.

   a. Equipment noted to be removed and turned over to Owner shall be delivered to Owner at place and time Owner designates.

   b. 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.

6. 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.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.

1.5 REFERENCES AND STANDARDS

A. Design, cable and component selection, and installation practices shall conform with following:

1. ANSI/NFPA 70 - National Electrical Code
2. Local Electrical Code
3. Country, state and local health, safety and building codes
4. UL 444 - Communications Cables
5. University of Kentucky - Communications and Network Systems – Telecommunications Standards (latest version)
6. BICSI Telecommunications Distribution Methods Manual (TDMM)

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

1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials
4. BICSI Building Industry Consulting Services International
5. EIA Electronic Industries Alliance
6. FIPS Federal Information Processing Standards
7. FCC Federal Communications Commission
8. ICEA Insulated Cable Engineers Association
9. IEEE Institute of Electrical and Electronics Engineers
10. JCAHO Joint Commission on Accreditation of Healthcare Organizations

11. NEC National Electrical Code
12. NECA National Electrical Contractors Association
13. NEMA National Electrical Manufacturers Association
14. NESC National Electrical Safety Code
15. NETA National Electrical Testing Association
16. NFPA National Fire Protection Association
17. NIST National Institute of Standards and Technology
18. OSHA Occupational Safety and Health Administration
19. TIA Telecommunications Industry Association
20. UL Underwriters Laboratories, Inc.

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

1.6 DEFINITIONS

A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.

1. Entrance facility - an entrance to building for both public and private network service cables and/or wireless services including entrance point of building and continuing to Entrance Room.
2. Entrance Room - room where both public and private network service cables and/or wireless services are terminated. Service provider(s) point-of-demarcation (DEMARC) is typically located here.
3. Equipment Room (Telecom): an environmentally controlled centralized space for telecommunications equipment that usually houses main or intermediate cross-connect. Backbone cabling, cabling to Building Entrance and horizontal cabling may be terminated here.
4. Equipment Intermediate Distribution Facility – Centralized space for security, building automation, fire alarm and/or other low-Voltage equipment.
5. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
6. Intra-building - within single building.
7. Inter-building - between 2 or more buildings.
8. IP Telephony – Use of Internet Protocol (IP) for two-way transmission of conversations. Sometimes referred to as “Voice over Internet Protocol (VoIP)”.
9. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1-3/4” high.
10. Voice over Internet Protocol – See IP Telephony.

B. Typical NEMA Enclosures and Usage

1. Refer to Section 26 0000 – General Electrical Requirements.
2. NEMA 1 - Indoors. Falling dirt

3. NEMA 2 - Indoors. Falling dirt. Falling liquids. Light splashing
4. NEMA 3 - Outdoors. Sleet, snow, rain. Windblown dust
5. NEMA 3X - Same as NEMA 3 plus corrosion resistant
6. NEMA 3S - Same as NEMA 3 plus mechanism operable when ice covered
7. NEMA 3SX - Same as NEMA 3S plus corrosion resistant
8. NEMA 3R - Outdoors. Rain, snow, sleet
9. NEMA 3RX - Same as NEMA 3R plus corrosion resistant
10. NEMA 4:
    a. Indoors - Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down
    b. Outdoors - Rain, sleet, snow. Wind blown dust. Hose down
11. NEMA 4X - Same as NEMA 4 plus corrosion resistant
12. NEMA 5 - Indoors. Falling Dirt. Falling Liquids. Settling dust, lint and fibers
13. NEMA 6:
    a. Indoors - Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down. Temporary submersion.
    b. Outdoors - Rain, snow, sleet. Windblown dust. Hose down. Temporary submersion.
14. NEMA 6P:
    a. Indoors - Same as NEMA 6 / Indoors plus corrosion resistant. Prolonged submersion.
    b. Outdoors - NEMA 6 /Outdoors plus corrosion resistant. Prolonged Submersion.
15. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
16. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
17. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.
18. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.]

1.7 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.

1. AC Access Control
2. AFF Above Finished Floor
3. AP Wireless Access Point
4. ATM Asynchronous Transfer Mode
5. AWG American Wire Gauge
6. BAS Building Automation Systems
7. BDF Building Distribution Facility
8. BEF Building Entrance Facility
9. BTU British Thermal Unit
10. CATV Community Antenna Television
11. CCTV Closed-Circuit Television

12. CFOI Contractor Furnished, Owner Installed
13. CDDI Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
14. cm centimeters
15. CNS UK- Communications and Network Systems
16. °C degrees Celsius
17. °F degrees Fahrenheit
18. DTMF Dual Tone Multi Frequency
19. EIA Electronic Industries Alliance
20. EBDF Equipment Building Distribution Facility
21. EIDF Equipment Intermediate Distribution Facility
22. EMT Electrical Metallic Tubing
23. FDDI Fiber Distributed Data Interface
24. ft feet
25. FTP Foiled Twisted Pair
26. GbE Gigabit Ethernet
27. 10GbE 10 Gigabit Ethernet
28. HCP Horizontal Connection Point
29. Hz Frequency in Hertz (k = kilo, M = Mega, G = Giga)
30. ID Inside Diameter
31. IDF Intermediate Distribution Facility
32. in inch
33. kg kilogram
34. lbs pounds
35. LAN Local Area Network
36. MATV Master Antenna Television
37. MC Main Cross-connect
38. m meters
39. mm millimeters
40. Mbps Megabits per second
41. µm micrometer (10^{-6} meter)
42. OD Outside Diameter
43. PBX Private Branch Exchange (Telephone Switch)
44. pF pico-Farad (10^{-12} Farad)
45. PVC Polyvinyl Chloride
46. RGC Rigid Galvanized Conduit
47. RU Rack Unit
48. SCS Structured Cable System
49. sq ft square feet (area)
50. TGB Telecommunications Grounding Busbar

51. TMGB Telecommunications Main Grounding Busbar
52. TP-PMD Twisted Pair Physical Layer Medium
53. UTP Unshielded Twisted Pair
54. WAN Wide Area Network
55. WAO Work Area Outlet
56. WLAN Wireless Local Area Network
57. VoIP Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.8 WORK BY OWNER

A. Owner will:
   1. Furnish active LAN electronics for interface with building voice and data cabling systems.
   2. Provide and install owner-furnished patch cords within IDF rooms, or distribute owner-furnished patch cords to appropriate vendors for installation.
   3. Coordinate all third-party vendor equipment and installation not included in Division 27 Specifications and drawings

1.9 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.10 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:
   1. Refer to Division 01 - Submittal Procedures.
   2. Submit shop drawings for equipment and systems as requested in respective specification sections. Submittals which are not requested may not be reviewed.
   3. Mark general catalog sheets and drawings to indicate specific items submitted.
   4. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   5. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Submittals shall be clearly marked and noted accordingly.
   6. Submittals should be grouped to include complete documentation of related systems, products and accessories in single submittal. Where applicable, dimensions shall be marked in units to match those specified.
   7. Submittals shall be in electronic form (ADOBE *Acrobat* PDF) or on paper.
      a. Paper documents shall be original catalog sheets or photocopies thereof.
      b. Facsimile (fax) sheets will not be accepted.
      c. When multiple products are shown on a page, clearly indicate what item is proposed for use.

8. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
9. Include wiring diagrams for electrically powered or controlled equipment.
10. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.
11. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
12. "Coordination Drawings", shall be specifically prepared for Divisions 20, 21, 22 and 23 (all trades) to facilitate installation of new work. Refer to Division 1 for additional requirements.
13. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
14. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.

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 - Closeout Procedures.
   2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2” thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
   3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
   4. Manuals shall include the following:
      a. Copies of shop drawings
      b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
      c. CD ROM's of O&M data with exploded parts lists where available
      d. Phone numbers and addresses of local parts suppliers and service companies
      e. Internet/WEB page addresses where applicable
      f. Wiring diagrams
      g. Start up and shut down procedure
      h. Factory and field test records
      i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
   5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
   6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.

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

1.11 QUALITY ASSURANCE

A. General:
   1. Refer to Division 1 for general Guarantee (Warranty) requirements.
   2. Cable and Equipment Manufacturer(s) shall be company specializing in communications equipment, cable, accessories and/or equipment with minimum of 5 years documented experience in producing products similar to those specified herein.

B. Refer to technical sections for Guarantee requirement for each system.
   1. Where no guarantee requirements are called out, guarantee as called out in Division 1 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. Contractor Qualifications:
   1. Qualified personnel utilizing state-of-the-art equipment and techniques shall complete system installation.
   2. Contractor shall have been in communications business for minimum of 5 years and shall provide references to 2 successfully completed projects equal to 50% of magnitude specified in the following sections.
   3. Contractor shall have minimum 1 RCDD (Registered Communications Distribution Designer) on permanent staff both at bidding and throughout the entire construction schedule.
   4. Minimum 50% of contractor technicians shall be certified under BICSI (Building Industry Consulting Services International) installation certification program.
   5. Contractor must provide a complete material listing at bid date with manufacturers, part numbers, and quantities prior to bid acceptance.
   6. Contractor project manager and technicians on site shall be manufacturer-trained to install shielded (F/UTP) copper cabling prior to F/UTP component installation.

1.12 JOB CONDITIONS

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

B. Cutting and Patching:
   1. Refer to General Conditions of Contract, and Division 01 - Cutting and Patching.
   2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged, to original condition. This includes openings remaining from removal or relocation of existing system components.
   3. Provide materials required for patching unless otherwise noted.

4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

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

1.13 GUARANTEE

A. General:
1. Refer to Division 01 for general Guarantee (Warranty) requirements.
2. Cable and Equipment Manufacturer(s) shall be company specializing in communications equipment, cable, accessories and/or equipment with minimum of 5 years documented experience in producing products similar to those specified herein.

B. Refer to technical sections for Guarantee requirement for each system.
1. Where no guarantee requirements are called out, guarantee as called out in Division 1 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 Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.

E. Guarantees shall include labor, material and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Product substitutions are not allowed without written approval from owner.

PART 3 - EXECUTION

3.1 GENERAL

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

B. Contractor shall coordinate with owner & engineer on final raceway counts, conduit quantities, and equipment room fitting quantities.

C. Division 26 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

D. Division 26 Contractor shall provide all grounding and bonding infrastructure as specified and shown on plans, including but not exclusive to Communications grounding backbone, Communications ground bars, and interconnecting grounding and bonding conductors.

1. Division 26 Contractor shall provide all Telecommunications Grounding Busbars (TGBs).
2. Division 26 Contractor shall provide and terminate grounding conductors from Division 26-provided infrastructure to the closest Communications Grounding Busbar located in each of the BDF and IDF rooms

3.2 DELIVERY, STORAGE, AND HANDLING

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

B. Store and protect products under provisions of Division 01.

C. Store in clean, dry space.

D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer's written instructions.

F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

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

B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted.

C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.

D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.

E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.

G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls. Indicate and locate, by dimension, required

openings including those sleeved, formed or core drilled. Drawings shall be approved by the structural engineer prior to preparing openings in structural member.

H. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.

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

J. Seal non-rated wall openings with urethane caulk.

K. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.

L. Finish and trim penetrations as shown on details and as specified hereinafter.

M. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Owner.

B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.

D. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

E. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless noted otherwise.

3.5 EQUIPMENT SUPPORTS

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

B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.

C. Do not support equipment or cable pathways from metal roof decking.

3.6 SUPPORT PROTECTION

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

B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.7 ACTIVE ELECTRONICS

A. Contractor shall:
   1. Unpack and install Owner-furnished 802.11 wireless access point units at the locations of the type-C data outlets noted on the drawings.
      a. Quantity: refer to drawings.
      b. Connect each unit to local data outlet with owner furnished yellow patch cord.
      c. Record each unit's MAC # and install Owner-furnished label.

B. Coordinate with owner exact device locations prior to beginning work.

3.8 HOUSEKEEPING PADS

A. Not applicable to this Division of work.

3.9 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 maintain that integrity. Coordinate these requirements with Trade Contractor.

3.10 ACCEPTANCE TESTING

A. Prior to testing, submit to owner (or owners representative) and Engineer, proposed schedule for acceptance testing.
   1. This notification shall be minimum of ten (10) working days in advance to allow for participation by Owner and/or Engineer.

B. Prior to testing, submit written description of intended test procedures and submit sample test forms to Engineer.
   1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
   2. Failure to provide above information shall be grounds for Engineer or Owner to reject any Documentation of related testing and to require repeat of affected test.

C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
   1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.

D. Provide equipment and personnel necessary to conduct acceptance tests.

E. Testing shall be completed and accepted by Owner and Engineer before Owner furnished equipment and cross connects are installed.

F. Document tests.

G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to the owner. Replacement materials shall be new.

H. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

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

J. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.11 START-UP

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

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

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

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

E. Coordinate start-up with trades.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.12 DOCUMENTATION

A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
   1. Acceptance Test Results
   2. Record Drawings
   3. All Approved Submittals
   4. Manufacturer’s Warranty Documents

B. Submit System Documentation in accordance with Division 01 "Project Record Documents".

C. Submit documentation within ten (10) working days of the completion of installation of system.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.

D. Submit Acceptance Test Results in electronic form for review and distribution.
   1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
   2. Final documentation of Test Results shall be submitted on CD-ROM.
   3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.
   4. Where unique software (other than an MS-Word™ compatible Word Processor or MS-Excel™ spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, one licensed copy of such software. Software shall run on MICROSOFT Windows-based personal computer.

E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

F. Engineer or Owner may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
   1. Owner may also perform independent testing to verify results.

2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.

G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Owner.
   1. Refer also to Technical Sections for requirements specific to covered subsystems

H. Documentation - including hard copy of Record Drawings - shall become property of Owner.

I. Refer also to Technical Sections for requirements specific to covered subsystems.

3.13 CLEANING

A. After installation is complete, Contractor shall clean all systems.

B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.

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

END OF SECTION

SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Communications Grounding and Bonding.

1.2 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27-0000 - General Communications Requirements
2. Section 27-0528.29 - Hangers and Supports for Communications Systems
3. Section 27-0528.33 - Raceway and Boxes for Communications Systems
4. Section 27-0528.36 - Cable Tray for Communications Systems
5. Section 27-0553 - Communications Systems Identification
6. Section 27-1100 - Communications Equipment Room Fittings
7. Section 27-1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:

1. Section 26-0526 - Grounding and Bonding for Electrical Systems

1.3 REFERENCES AND STANDARDS

A. Refer to Section 27-0000 - General Communications Requirements that identifies pertinent References and Standards.

B. In addition, the following apply:

1. IEEE/ANSI 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. UL 467 Electrical Grounding and Bonding Equipment
3. ANSI J-STD-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
4. NEC Article 250 – Grounding
5. NEC Article 800 – Communications Circuits
6. NFPA 78 – Lightning Protection

1.4 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 27-0000 - General Communications Requirements which provides information on Definitions and Abbreviations used in this and related sections.

B. Additional definitions (per referenced standards):

1. 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. For the UK-RB2 project, the Main Grounding Busbar (MGB) in the basement level BDF room shall serve as the TMGB.
2. Telecommunications Grounding Busbar (TGB): interface to building telecommunications grounding system generally located in telecommunications room. Common point of connection for telecommunications system and equipment bonding to ground, and located in telecommunications room or equipment room.
3. Telecommunications Bonding Conductor: conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.
4. Telecommunications Bonding Backbone (TBB): conductor that interconnects telecommunications main grounding busbar (TMGB) to telecommunications grounding busbar (TGB).
5. Grounding Equalizer (GE): conductor that interconnects elements of telecommunications grounding infrastructure.
6. Exothermic Weld: method of permanently bonding two metals together by controlled heat reaction resulting in molecular bond.
7. Irreversible Compression: permanent mechanical bond between conductors or conductor and connector using mechanical or hydraulic tool.

1.5 WORK BY OWNER

A. Refer to Section 27-0000 - Structured Cabling which identifies Work by Owner affecting subsystem(s) covered by this section.

1.6 SUBMITTALS

A. Refer to Section 27-0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

B. Refer to Section 26-0526 – Grounding and Bonding for Electrical systems which provides submittal guidelines for Division 26-provided components.

1.7 QUALITY ASSURANCE

A. Refer to Section 27-0000 - General Communications Requirements which identifies general quality assurance requirements for the Project.

1.8 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

PART 2 PRODUCTS

2.1 TELECOMMUNICATIONS GROUNDING BUSBARS

A. Material: Copper (aluminum not permitted)
   1. 1/4" thick

B. Pre-drilled
   1. 3/8" Diameter
   2. Hole spacing per ANSI Joint Standard J-STD-607-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. Busbars shall be listed by nationally recognized testing laboratory.

E. Size:
   1. Telecommunications Main Ground Busbar (TMGB) - 24" x 4" (minimum)
   2. Telecommunications Grounding Busbar (TGB) - 12" x 2" (minimum)

2.2 CONDUCTORS

A. Material: Stranded copper (aluminum not permitted)

B. Bonding Conductors shall be insulated.
   1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines

C. Size:
   1. Telecommunications Bonding Conductor (TMGB to Grounding Electrode):
      a. Refer to drawings.
   2. Telecommunications Bonding Backbone (TBB; TMGB to TGB):
      a. Refer to drawings.
   3. Grounding Equalizer (GE):
      a. Refer to drawings.

2.3 CONNECTIONS

A. Mechanical Connectors
   1. Connector Body shall:
      a. Be high-strength, high-conductivity cast copper alloy
      b. Be 2 bolt type
   2. Bolts, nuts, washers and lock-washers: Silicon Bronze
      a. Shall be supplied as part of connector body
      b. Split bolt connector types are not allowed

3. Connector shall:
   a. Meet or exceed UL 467
   b. Be clearly marked with catalog number, conductor size and manufacturer.

B. Compression Connectors
1. Connector Body: pure wrought copper.
   a. Conductivity shall be no less than 99% by IACS standards.
2. Connector shall:
   a. Meet or exceed performance requirements of IEEE 837, latest revision
   b. Be factory filled with an oxide-inhibiting compound
   c. Be clearly marked with manufacturer, catalog number, conductor size and required compression tool settings
3. Connection shall be irreversible.

C. Exothermic connections are not allowed on Communications grounding and bonding components.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide Telecommunications grounding and bonding infrastructure as specified and shown on plans, including Telecommunications grounding backbone, Telecommunications ground bars, and interconnecting grounding and bonding conductors.
1. Division 26 Contractor shall provide and terminate grounding conductors from Division 26-provided infrastructure to the closest Telecommunications Grounding Busbar located in each of the BDF and IDF rooms.

B. Division 27 Contractor shall provide and terminate Telecommunications grounding conductors from Division 27-provided equipment to the closest Telecommunications Grounding Busbar located in each of the BDF, MDF, and IDF rooms.

3.2 SEQUENCING AND SCHEDULING

A. Permanently attach all Telecommunications grounds prior to energizing communications equipment.

3.3 INSTALLATION

A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.

B. Install Products in accordance with manufacturer's instructions.
1. Install Compression Connectors with compression, tool and die system, as recommended by manufacturer of connectors.

C. Grounding connections shall be tight and shall be made with UL listed grounding devices, fittings, bushings, etc.

D. On the Telecommunications Bonding Conductor, Telecommunications Bonding Backbone (TBB) and Grounding Equalizer (GE) all connections shall be Compression type.

E. Locate TGBs and TMGB per drawings.

F. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
   1. TGBs shall be bonded to TBB via tap off of TBB.
      a. Exception is "last" TGB on TBB (e.g. furthest from TMGB).
   2. Grounding Equalizer(s) (GE) shall connect to TGBs to be interconnected.

G. Insulate Busbars from their support.

H. Connections shall be bare metal to bare metal contact.
   1. Clean surfaces of paint, dirt, oil, etc.

I. Connections shall be exposed and visible for inspection at all times.
   1. Do not install insulation over ground connections.

J. Terminate each grounding conductor on its own terminal lug.
   1. Multiple conductors on single lug not permitted.

3.4 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

3.5 DOCUMENTATION

A. Accurately record actual locations of grounding electrode(s), busbars and backbone grounding conductors.

END OF SECTION

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SECTION 27 0528.29 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION

A. Unless noted otherwise, all hangers and supports shall be provided by the Division 26 Contractor.

B. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

1.2 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27-0000 - General Communications Requirements
   2. Section 27-0526 - Grounding and Bonding for Communications Systems
   3. Section 27-0528.33 - Raceway and Boxes for Communications Systems
   4. Section 27-0528.36 - Cable Tray for Communications Systems
   5. Section 27-0553 - Communications Systems Identification
   6. Section 27-1100 - Communications Equipment Room Fittings
   7. Section 27-1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26-0529 - Hangers and Supports for Electrical Systems

1.3 REFERENCE

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

PART 2 PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 2 for all products identified in Part 1.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide all Division 27 hangers, supports, and related devices as specified and shown on drawings.

3.2 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26-0529 - Hangers and Supports for Electrical Systems - Part 3 for all products identified in Part 1.

END OF SECTION

SECTION 27 0528.33 RACEWAY AND BOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Unless otherwise noted, all raceway and boxes shall be provided by the Division 26 Contractor.

B. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

C. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 1 for requirements for Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee for:
   1. Outlet Boxes
   2. Pull and Junction Boxes
   3. Raceways and Wireways (including sleeves, expansion fittings, penetrations, and seals)
   4. Indoor Service Poles
   5. Poke-through Fittings
   6. Floor Boxes
   7. Cable Supports

1.2 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 0000 - General Communications Requirements
   2. Section 27-0526 - Grounding and Bonding for Communications Systems
   3. Section 27-0528.29 - Hangers and Supports for Communications Systems
   4. Section 27-0528.36 - Cable Tray for Communications Systems
   5. Section 27-0553 - Communications Systems Identification
   6. Section 27-1100 - Communications Equipment Room Fittings
   7. Section 27-1300 - Communications Backbone Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0533 - Raceway and Boxes for Electrical Systems

1.3 REFERENCES

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

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 2 for Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

2.2 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY

A. Manufacturers: Carlon, Pyramid, or approved equal.

B. Size innerduct for maximum 40% fill (cable vs. innerduct I.D.). Minimum innerduct duct size shall be 1-1/4” inch (I.D.) unless otherwise noted on drawings.

C. Indoor Innerduct shall be:
   1. Corrugated
   2. Riser rated.

D. Innerduct Color shall be as follows:
   1. Riser: ORANGE

PART 3 - EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide all Division 27 grounding and bonding infrastructure as specified and shown on plans, including but not exclusive to Communications grounding backbone, Communications ground bars, and interconnecting ground cables.

B. Division 27 Contractor shall provide and terminate grounding conductors from Division 27-provided infrastructure to the closest Communications Grounding Busbar located in each of the BDF and IDF rooms

3.2 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 3 for Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 2.

3.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY (INNERDUCT)

A. Flexible Non-metallic Innerduct (e.g. "Innerduct") shall be provided as follows:
   1. As protection to backbone fiber optic cables installed in conduits, cable tray or cable support hooks
   2. As protection to fiber optic cable(s) within telecommunications equipment rooms

B. Extend innerduct to termination and/or cable storage enclosure.

C. Provide couplings designed for innerduct size and type where innerduct enters a termination or storage enclosure.

D. Where not installed in a continuous length, splice innerduct segments using couplings designed for that purpose.

E. Provide nylon pull cord in empty innerduct and cap innerduct at both ends.

F. Label innerduct where entering and exiting all junction boxes, pull boxes, and enclosures, and at 10 ft intervals where exposed with tags indicating cable type and cables contained therein.

END OF SECTION

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SECTION 27 0528.36 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SCOPE

A. Unless noted otherwise, all cable tray shall be provided by the Division 26 Contractor.

B. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

C. Cable tray system is intended to support Division 27-provided cable only.

1. A/C power wiring and fire alarm system cabling are not allowed in cable tray.
2. All D/C power wiring shall be approved by the Engineer prior to installation.
    a. Four-pair copper Communications cables utilizing IEEE 802.af Power over Ethernet (PoE) are exempt from this requirement.

1.2 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27-0000 - General Communications Requirements.
2. Section 27-0526 - Grounding and Bonding for Communications Systems
3. Section 27-0528.29 - Hangers and Supports for Communications Systems
4. Section 27-0528.33 - Raceway and Boxes for Communications Systems
5. Section 27-0553 - Communications Systems Identification
6. Section 27-1100 - Communications Equipment Room Fittings
7. Section 27-1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:

1. Section 26-0529 - Hangers and Supports for Electrical Systems
2. Section 26-0536 - Cable Trays for Electrical Systems

1.3 REFERENCE

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

PART 2 PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26-0529 - Hanger and Supports for Electrical Systems - Part 2 for products identified in Part 1.

B. Refer to Section 26-0536 - Cable Trays for Electrical Systems - Part 2 for products identified in Part 1.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including but not exclusive to back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

3.2 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26-0529 – Hangers and Supports for Electrical Systems - Part 3 for products identified in Part 1.

B. Refer to Section 26-0536 - Cable Trays for Electrical Systems - Part 3 for products identified in Part 1.

END OF SECTION

SECTION 27 0537 -COMMUNICATIONS SYSTEM FIRESTOPPING

PART 1 GENERAL

1.1 SCOPE

A. This Section details product and execution requirements for Communications System Firestopping.

1.2 DESCRIPTION

A. Furnish and install work under this Section including the following:

1. Post-cable installation penetrations within Communications raceways through fire-resistance-rated floor, roof, walls, and partitions including openings containing conduits, cables, cable bundles, cable tray and other penetrating items.
2. Firestopping systems and installation shall provide fire rating equal to that of construction being penetrated.
3. Proposed firestop materials and methods shall conform to applicable code requirements of authority having jurisdiction.

1.3 RELATED WORK

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

B. Related Division 27 Sections include:

1. Section 27-0000 - General Communications Requirements
2. Section 27-0528.33 - Raceway and Boxes for Communications Systems
3. Section 27-0528.36 - Cable Trays for Communications Systems
4. Section 27-1100 - Communications Equipment Room Fittings
5. Section 27-1300 - Communications Backbone Cabling

C. Related sections in other Divisions of Work:

1. Section 26-0000 - General Electrical Requirements
2. Section 26-0533 - Raceway and Boxes for Electrical Systems
3. Section 26-0536 - Cable Trays for Electrical Systems
4. Section 26-0593 - Electrical System Firestopping

1.4 REFERENCE

A. Refer to Section 27-0000 - General Communications Requirements which identifies related specification sections in this and other Divisions (if applicable).

1.5 REFERENCE STANDARDS

A. UL 1479 - Fire Tests For Through-Penetration Firestops

B. UL 2079 - Tests For Fire Resistance of Building Joint Systems

1.6 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed firestopping systems that are similar in material, design, and extent to that indicated for this Project and that have performed successfully.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc, or Rectorseal Corp.

2.2 MATERIALS

A. Use only firestop products that have been UL 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. Materials shall not contain flammable solvents.

C. Use removable pillow type fire stop material with cable tray.

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 PROJECT CONDITIONS

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

B. Ventilate firestopping per manufacturers' instructions by natural means or, where this is inadequate, forced air circulation.

3.3 DELIVERY 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. Handle with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

3.4 PREPARATION

A. Confirm cable installation is complete prior to beginning work.

B. Clean out openings immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer.

C. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

D. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.5 INSTALLATION

A. Comply with manufacturer's installation instructions and drawings.

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

C. Avoid multiple penetrations of common fire barrier opening. When possible, seal each penetration in accordance with project details.

D. Firestopping devices and equipment shall be red in color.

3.6 SEQUENCING AND SCHEDULING

A. Do not cover up firestopping installations that will become concealed behind other construction until authorities having jurisdiction, if required, have examined each installation.

B. Where deficiencies are found, repair or replace firestopping so that it complies with requirements.

3.7 CLEANING

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

END OF SECTION

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SECTION 27 0553 - COMMUNICATIONS SYSTEMS IDENTIFICATION

PART 1 GENERAL

1.1 SCOPE

A. This Section details product and execution requirements for labeling of communications cabling, termination components, pathways, and spaces.

B. All components shall be clearly labeled to identify them as unique throughout the Project.

1.2 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27-0000 - General Communications Requirements
2. Section 27-0526 - Grounding and Bonding for Communications Systems
3. Section 27-0528.29 - Hangers and Supports for Communications Systems
4. Section 27-0528.33 - Raceway and Boxes for Communications Systems
5. Section 27-0528.36 - Cable Trays for Communications Systems
6. Section 27-1100 - Communications Equipment Room Fittings
7. Section 27-1500 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:

1. See individual technical sections identified above (if applicable).

1.3 REFERENCES AND STANDARDS

A. Refer to Section 27-0000 - General Communications Requirements which identifies pertinent References and Standards.

B. Other applicable references and standards include:

1. TIA/EIA-606-B - Administration Standard for Commercial Telecommunications Infrastructure.

1.4 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 27-0000 - General Communications Requirements which provide information on Definitions and Abbreviations used in this and related sections.

1.5 SUBMITTALS

A. Refer to Section 27-0000 - General Communications Requirements which provide general guidelines for product and/or installation information to be submitted by Contractor.

B. Prior to installation, provide samples of label types planned for the Project.

1. Samples shall include examples of lettering to be used and shall follow standards detailed below.

1.6 QUALITY ASSURANCE

A. Refer to Section 27-0000 - General Communications Requirements which identifies general quality assurance requirements for the Project.

PART 2 PRODUCTS

2.1 GENERAL

A. Labels and markings shall be physically and chemically resistant to damage that would make label unreadable.

B. Cable labels shall be self-laminating, White/Transparent Vinyl and incorporate an integrated clear lamination which, when label is wrapped around cable, covers printed part of label.

1. Labels shall be of adequate size to accommodate circumference of cable(s) being marked and properly self-laminate over full extent of printed area of label.

2. Labels on larger cables (e.g. Copper Backbone) may be wrapped with clear non-removable tape.

PART 3 EXECUTION

3.1 GENERAL

A. Coordinate labeling requirements with University of Kentucky CNS Department.

B. All patch panels, connecting blocks, optical fiber panels, and grounding busbars must be properly labeled per TIA/EIA 606 and BICSI TDMM.

C. Labeling shall be by mechanical means.

1. Hand lettered designations are not allowed.

D. Tags shall be non-removable.

1. Exceptions:
   a. Telecommunications Ground tags secured with cable ties.
   b. Innerduct Tags secured with cable ties.

E. Characters shall be Black Ink and printed on background of contrasting color.

F. Labels shall match hardware layout and design.

G. Labels shall be as large as practicable while fitting properly.

H. No lettering shall be smaller than 10-point.

I. Label cables with tag which is wrapped around cable sheath.
   1. Clean cable sheath thoroughly before applying label.
   2. Position label as to be visible and not obscured by termination hardware.

3.2 ROOM IDENTIFICATION

A. BDF and IDF room number shall match architectural room numbers as shown on drawings.

3.3 EQUIPMENT RACK IDENTIFICATION

A. All racks and distribution frames must be properly labeled per TIA/EIA 606 and BICSI TDMM.

3.4 TELECOMMUNICATIONS OUTLET

A. Label each telecommunications outlet port with unique identifying code.

   1. Top Label of Outlet:
      a. Room Number of Outlet Location
      b. Location in room going clockwise starting at corridor door (1,2,3…)
         1). Example: In room AO6112, the top of the first faceplate going clockwise in the room shall be labeled:

AO6112-1

   2. Bottom Label of Outlet:
      a. Room Number of source IDF/EIDF Room
      b. Patch panel ID
      c. Patch panel port number (1, 2, 3…)
         1). Example: In room AO6112, the bottom of the first faceplate going clockwise in the room shall be labeled:

AO6C002-A-1,2

3.5 WIRELESS ACCESS POINT OUTLET

A. Label each wireless access point outlet port with unique identifying code.

   1. Top Label of Outlet:
      a. Room Number of Outlet Location
      b. AP
      c. Location in room/space going clockwise (1,2,3…)
         1). Example: In room AO6112, the top of the first wireless access point faceplate going clockwise in the room/space shall be labeled:

AO6112-AP-1

   2. Bottom Label of Outlet:

a. Room Number of source IDF/EIDF Room
b. Patch panel ID
c. Patch panel port number (1, 2, 3…)
    1). Example: In room AO6112, the bottom of the first faceplate going clockwise in the room shall be labeled:

AO6C002-A-1, 2

3.6 MODULAR PATCH PANEL

A. All patch panels, connecting blocks, optical fiber panels, and grounding busbars must be properly labeled per TIA/EIA 606 and BICSI TDMM.

B. Label each patch panel in each rack in alphabetical order (A,B,C…) starting at the top of each rack. Labels shall be unique within each room.

C. Label each patch panel port:

1. Faceplate ID

2. Jack ID
    a. Example: In for the data jack 1 in the faceplate 1 within room AO6112:

AO6112-1-1

D. Coordinate and confirm labeling requirements with University of Kentucky CNS Department.

3.7 COAXIAL PATCH PANEL

A. Label each patch panel in each rack in alphabetical order (A,B,C…) starting at the top.

B. Label each patch panel port:

1. Faceplate ID
    a. Example: In for the coaxial jack 1 in the patch panel 1 within room AO6112:

AO6112-1-1

3.8 FIBER OPTIC PATCH PANEL

A. All patch panels, connecting blocks, optical fiber panels, and grounding busbars must be properly labeled per TIA/EIA 606 and BICSI TDMM.

B. Label each patch panel in each rack in alphabetical order (A, B, C…) starting at the top of each rack.

C. Label each patch panel port:

1. Faceplate ID

2. Jack ID
   a. Example: For the data jack 1 in the faceplate 1 within room AO6112:

AO6112-1 D1

3.9 HORIZONTAL CABLING

A. Label each horizontal cable at both ends at termination point with unique identifying code.

B. Label each end of horizontal cable to match patch panel label.

3.10 BACKBONE COPPER CABLE

A. Label each backbone cable at both ends at termination point with unique identifying code.

B. Label cable sheath:

1. At point where sheath ends
2. At point on cable where viewing of label is not obscured by termination blocks or other visual barrier.

C. Label shall be on plastic tag tie-wrapped to cable sheath, or placed on adhesive labels adhered to cable sheath.

1. If adhesive labels are used, cable sheath shall be cleaned thoroughly before applying label. Clear cellophane tape covering shall be placed over label to protect it and maintain adhesion to sheath.

D. Label Intra-building cables with:

1. From and To locations,
2. Pair Count,
3. Date installed.
4. Example 100-pair copper twisted pair cable from BDFAOB211 to IDFAO6015:

BDFAOB211- IDFAO6015
001-100
10/2019

E. Label Inter-building (between buildings) cables with:

1. Coordinate labeling requirements with University of Kentucky CNS Department.

3.11 TERMINATION BLOCKS

A. Termination Blocks shall be labeled with color-coded designation strips.

B. Label termination positions in horizontal row with position identifier.

C. Place termination block labels above or below termination.

D. IDF 110-style Cabling Blocks shall incorporate BLUE Designation Strips and shall be labeled consistent to patch panels.

E. Intra-Building (within building) 110-style Backbone Cabling Blocks shall incorporate WHITE Designation Strips and shall identify:

1. Cable Origin & Destination
   a. Repeat on every designation strip.
2. Pair #.
   a. Label 1st and 25th Positions on each row (e.g. 001 & 025, 026 & 050, etc.).
      1). Example BDFAOB211 to IDFAO6015:

001	BDFAOB211-IDFAO6015 025
026	BDFAOB211-IDFAO6015 050

F. Inter-Building (between buildings) Backbone Cabling Blocks shall incorporate BROWN Designation Strips and shall identify:

1. Cable Origin & Destination
   a. Repeat on every designation strip.
2. Pair #
   a. Label 1st and 25th Positions on each row (e.g. 001 and 025, 026 and 050, etc.).
      1). Example cable linking Building XXXXXX and PCF BDFA0B211:

001	XXXXXX- BDFAOB211	025
026	XXXXXX- BDFAOB211	050

3.12 BACKBONE FIBER OPTIC CABLING

A. Label each backbone cable at both ends at termination point with unique identifying code.

B. Label shall be placed on adhesive labels adhered to cable sheath.

1. Cable sheath shall be cleaned thoroughly before applying label.

C. Label Intra-building cables with:

1. From and To locations,
2. Fiber type (core/cladding diameter)
3. Fiber count
4. Date installed.
5. Example 36-fiber cable from BDFAOB211 to IDFAO6015:

BDFAOB211-
IDFAO6015
50/125 001-036
10/2019

D. Label Inter-building cables with:

1. From and To locations,
2. Fiber type (core/cladding diameter)
3. Fiber count
   a. Where multiple cables are installed between same end-points, labeling shall indicate sequential fiber numbering.
      1). For example 144-fibers provided as two 72-fiber cables would be labeled "001-072" and "073-144".
4. Date installed.
5. Example 72-fiber cable from Building GSH to PCF BDFA0B211:

GSH- BDFA0B211
50/125 001-072
10/2019

3.13 FIBER OPTIC PATCH PANELS

A. All patch panels, connecting blocks, optical fiber panels, and grounding busbars must be properly labeled per TIA/EIA 606 and BICSI TDMM.

B. Patch panel port labeling shall be consistent with Telecommunications Outlet and Horizontal Cabling labeling.

C. Coordinate labeling requirements with University of Kentucky CNS Department.

3.14 INNERDUCT

A. Innerduct containing fiber optic cable installed under this project shall be labeled where exposed.

1. Includes areas where innerduct is installed in trays and in equipment rooms.

B. Label innerduct with durable Yellow Polyethylene tag that reads "CAUTION FIBER OPTIC CABLE"

1. Tag shall provide blank spaces for adding fiber count and cable destination information.

C. Label Tag to include:

1. Identifier(s) of cable(s) contained therein.
   a. Use Backbone Cable labeling formats as described above.

D. Hand lettering is acceptable on tag

1. Use an indelible type ink.

E. Tag shall be secured to Innerduct using self-locking ties.

3.15 TELECOMMUNICATIONS GROUNDS

A. Label Grounds as close as practicable to point of termination.

B. Labels shall be non-metallic and include the following:

WARNING IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL UK-CNS.

END OF SECTION

SECTION 270800 - COMMISSIONING OF COMMUNICATIONS

Release: 09/2017

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 27 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in the Commissioning Plan (Cx Plan). Refer to Section 019100.

C. Commissioning requires the participation of the Division 27 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019100. Division 27 Contractor shall be familiar with all parts of Section 019100 and the commissioning plan issued by the CxA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Refer to the Cx Plan in the appendix of Section 019100.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 019100 - Commissioning
2. Section 220800 - Commissioning of Plumbing
3. Section 230800 - Commissioning of HVAC
4. Section 260800 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Digital multimeter capable of measuring voltage (AC/DC), current, and resistance.
2. Power quality and energy analyzer capable of capturing waveform (3 phase) and data recording.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 019100 for additional Division 27 requirements.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of Section 019100.

END OF SECTION - 270800

SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.1 SCOPE

A. This Section details product and execution requirements for Communications Equipment Room Fittings.

1.2 DESCRIPTION

A. Communication Equipment Room Fittings include:
   1. Cabinets, Racks, Frames, and Enclosures
   2. Cable and Wire Management
      a. Horizontal Cable Managers
   3. Cable Runway
   4. Termination Blocks
   5. Patch Panels

B. Refer to Project Drawings for Equipment Room layout and equipment placement.

1.3 RELATED WORK

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

B. Related Division 27 Sections include:
   1. Section 27-0000 - General Communications Requirements
   2. Section 27-0526 - Grounding and Bonding for Communications Systems
   3. Section 27-0528.29 - Hangers and Supports for Communications Systems
   4. Section 27-0528.33 - Raceway and Boxes for Communications Systems
   5. Section 27-0528.36 - Cable Tray for Communications Systems
   6. Section 27-0553 - Communications Systems Identification

C. Related sections in other Divisions of Work:
   1. Section 26-0526 Grounding and Bonding for Electrical Systems
   2. Section 26-0529 Hangers and Supports for Electrical Systems

3. Section 26-0553 - Raceway and Boxes for Electrical Systems
4. Section 26-0536 - Cable Trays for Electrical System

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27-0000 - General Communications Requirements which identifies related specification sections in this and other Divisions (if applicable).

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 27-0000 -General Communications Requirements which provide information on Definitions and Abbreviations used in this and related sections.

1.6 WORK BY OWNER

A. Refer to Section 27-0000 - General Communications Requirements which identifies Work by Owner affecting sub-system(s) covered by this Section.

1.7 SUBMITTALS

A. Refer to Section 27-0000 - General Communications Requirements which provide general guidelines for product or installation information to be submitted by Contractor.

1.8 QUALITY ASSURANCE

A. Refer to Section 27-0000 - General Communications Requirements which identify general quality assurance requirements for the Project.

1.9 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

PART 2 PRODUCTS

2.1 GENERAL

A. Patch Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA Documents.

B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.

1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.

2.2 CABINETS, RACKS, FRAMES AND ENCLOSURES

A. Manufacturers: Ortronics
   1. Ortronics part # OR-MM6716

B. Cable Management Racks shall:
   1. Be painted steel
      a. Color: Black
   2. Be 7’ high (45RU)
   3. Be 16.25” channel depth

2.3 CABLE MANAGEMENT

A. Manufacturers: Panduit
   1. Horizontal Cable Management Panel
      a. Ortronics part # OR-60400057

B. Horizontal Cable Management Panels shall:
   1. Be painted steel.
   2. Be 3.5" (2 RU) high
   3. Have minimum of 5 distribution rings (3.75" x 3.75" minimum dimension)
      a. Distribution rings shall be painted steel.

2.4 CABLE RUNWAY

A. Manufacturer: MonoSystems, Inc.
   1. UL Compliance: Products are UL classified and labeled

B. Cable Runway shall:
   1. Refer to Section 26 0536 - Cable Trays for Electrical Systems - Part 2 for products.
   2. Be listed by Underwriters Laboratories as an equipment grounding conductor.
   3. Comply with NEMA Standard VE1-2
   4. Comply with NEC Article 392
   5. Comply with NFPA 70B
   6. Be 4” deep sides
   7. Be minimum 18” wide. Refer to Project Drawings for sizing.

2.5 4-PAIR COPPER MODULAR PATCH PANELS

A. Manufacturers:
   1. Category 6A F/UTP: Commscope/Uniprise part # CPPA-SDDM-SL-2U-48
   2. Category 6 UTP: Commscope/Uniprise part # CPP-UDDM-SL-1U-24

2.6 COAXIAL PATCH PANELS

A. Manufacturers: Commscope part #1479450-1 or University of Kentucky ITS approved equal

2.7 TERMINATION BLOCKS

A. Manufacturers: Commscope/TE
   1. Rackmount 100-Pair 110 Block
      a. Commscope/TE part # 558635-1
   2. 300-Pair 110 Block Kit w/legs
      a. Commscope/TE part # 569446-1
   3. 100-Pair 110 Block Kit w/legs
      a. Commscope/TE part # 569440-1

B. Blocks shall be 110-style high-density cross-connect blocks.

C. Blocks shall meet or exceed TIA Category 5e performance criteria.

2.8 FIBER OPTIC PATCH PANELS

A. Manufacturers:
   1. Housing: Corning part # CCH-04U Coupling Panel:
      a. Backbone Coupling Panel, 8.3 micron Singlemode: Corning part # CCH-CP12-59
      b. Backbone Coupling Panel, 50 micron Multimode: Corning part # CCH-CP12-G7

B. Patch Panels shall:
   1. Be enclosed assemblies
   2. Incorporate hinged or retractable front cover
   3. Be rack mountable on standard TIA 19" equipment racks
   4. Provide for strain relief of incoming cables
   5. Incorporate radius control mechanisms to limit bending of fiber to manufacturer's recommended minimums of 1.2", whichever is larger
   6. Provide protection to both "facilities" and "user" sides of couplings.
   7. Be configured to require only front access when patching

8. Incorporate patch cable routing space internal to patch panel housing.
   a. Routing space shall be front-accessible.
9. Include provisions for permanent labeling of fiber optic cables.
   a. Labeling shall be accessible from front of patch panel and shall not require disassembly of patch panel housing or removal of front cover.
10. Coupling panels shall be provided with alignment sleeve.

C. Access to inside of panel housing during installation shall be from front and rear.
   1. Panels that require disassembly of housing to gain entry will not be accepted.

D. Incoming cables shall not be accessible from patching area of panel.
   1. Housing shall provide physical barrier to access of such cables.
   2. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, Housing shall incorporate hardware for securing of splice tray and required cable, buffer tube and pigtail slack.

PART 3 EXECUTION

3.1 GENERAL

A. Division 26 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.

B. Contractor shall provide necessary assistance to allow Owner or Carrier personnel to establish service on new cable system.
   1. Includes general wiring overview, cable pair identification, and cross connect documentation (if applicable).

3.2 CABLE MANAGEMENT

A. Provide horizontal cable management in equipment racks as follows:
   1. Provide one 2RU horizontal cable manager below every group of three horizontal patch panels in equipment racks.

3.3 MODULAR PATCH PANELS

A. Provide panels as needed to accommodate new horizontal link cables.

B. Mount patch panels in existing 19" equipment racks.

C. Position cables in sequence of:

1. Telecommunications Outlet ID for horizontal cabling
2. Pair number for backbone cabling

D. Provide minimum of 4 screws to secure each patch panel onto rack.

3.4 FIBER OPTIC PATCH PANELS

A. Provide Fiber Optic Patch Panel housings and coupling panels as required per backbone and horizontal cable counts.

B. Provide patch panels and horizontal cable management in existing 19" equipment racks.

C. Provide coupling panels and mount in patch panel housings.

D. Position fibers consecutively - starting with lowest number - and mapped "position for position" between patch panels.

1. There shall be no transpositions in cabling per TIA T568C.

E. Provide blank covers for unused coupling assembly spaces in panels.

F. Clean couplings with foam swab and isopropyl alcohol prior to connector insertion. Blow dry with canned compressed air.

G. Provide dust caps for couplings.

H. Provide minimum of 4 screws to secure each patch panel onto rack.

END OF SECTION

SECTION 27-1500 COMMUNICATIONS HORIZONTAL CABLING

PART 1 GENERAL

1.1 SCOPE

A. This Section details product and execution requirements for Horizontal (Station) Cabling subsystem.

B. Horizontal cabling subsystem is portion of communication link that connects horizontal or intermediate cross-connect (typically at IDF room) and Communications Outlet.

1.2 DESCRIPTION

A. Communications Horizontal Cabling includes:

1. 4-Pair Cable
   a. Category 6A F/UTP
2. Coaxial Cable
3. Communications Faceplate
4. 4-Pair Modular Jack
5. Coaxial Connector

1.3 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27-0000 - General Communications Requirements
2. Section 27-0526 - Grounding and Bonding for Communications Systems
3. Section 27-0528.33 - Raceway and Boxes for Communications Systems
4. Section 27-0528.36 - Cable Trays for Communication Systems
5. Section 27-0528-39 - Surface Raceways for Communication Systems
6. Section 27-0553 - Communications Systems Identification
7. Section 27-1100 - Communications Equipment Room Fittings
8. Section 27-1300 - Communications Backbone Cabling

B. Related sections in other Divisions of Work:

1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27-0000 - General Communications Requirements which identifies pertinent References and Standards and other published documents that are applicable to this scope of work.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 27-0000 - General Communications Requirements which provide information on Definitions and Abbreviations used in this and related Sections.

B. In this Section, "Communications Outlet" is considered to consist of Frame / Faceplate into which Modular Jacks or other couplings snap, Modular Jacks, blank for unused jack positions, and labeling/identification components.

1.6 WORK BY OWNER

A. Refer to Section 27-0000 - Structured Cabling which identifies Work by Owner affecting sub-system(s) covered by this Section.

1.7 SUBMITTALS

A. Refer to Section 27-0000 - General Communications Requirements which provide general guidelines for product or installation information to be submitted by Contractor.

B. Submit:

1. Samples of each Communications Outlet faceplate to confirm color and material.
2. Samples of each Communications jack to confirm color & material.
3. One 3-foot section of each cable type from cable reels sent to site for Engineer's final approval.
    a. Section shall have manufacturer's cable markings visible.
4. Nominal Velocity of Propagation (NVP) for 4-pair Horizontal Copper Cable.

1.8 QUALITY ASSURANCE

A. Refer to Section 27-0000 - General Communications Requirements which identify general quality assurance requirements for the Project.

1.9 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to all cable and components covered in this section.

PART 2 PRODUCTS

2.1 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA/EIA Documents.

B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.

1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.

D. Horizontal Cable types include:

1. 4-pair copper Foiled Twisted Pair (F/UTP)
2. Coaxial

2.2 4-PAIR HORIZONTAL 4-PAIR COPPER CABLE

A. Manufacturers: Commscope/Uniprise
1. Category 6A F/UTP Green: Commscope/Uniprise part # UN884029304/10 CS44R series
2. Category 6 UTP: Commscope/Uniprise part # UN88402#### (#### identifies jacket color and packaging) CS37R series

B. Cables shall be suitable for installation in environment defined

C. Cabling shall be packaged to minimize tangling and kinking of cable during installation.

D. Configuration:
1. Number of Pairs: 4 twisted pair
   a. Pair twists of any pair shall not be same as any other pair within each cable.
   b. Pair twist lengths shall be selected by manufacturer to ensure compliance with crosstalk requirements of TIA/EIA 568-B.2
2. Conductors: insulated solid annealed copper pairs
   a. Category 6A F/UTP: 23 AWG
   b. Category 6 UTP: 23 AWG
3. Jacket Type: PVC
4. Drain Wire
   a. F/UTP: Yes
   b. UTP: No

5. Cable Rating: NEC Article 800 Type CMR, UL listed

E. Pairs of 4-pair cables shall be identified by banded color code in which conductor insulation is marked with dominant color and banded with contrasting color.
   1. By pair number, pair colors or dominant band shall meet TIA 568B configuration:
      a. Pair 1: Tip - White/Blue; Ring - Blue (or Blue/White)
      b. Pair 2: Tip - White/Orange; Ring - Orange (or Orange/White)
      c. Pair 3: Tip - White/Green; Ring - Green (or Green/White)
      d. Pair 4: Tip - White/Brown; Ring - Brown (or Brown/White)

F. Horizontal cable shall:
   1. Category 6A F/UTP:
      a. Meet or exceed TIA Category 6A 10-Gigabit F/UTPperformance requirements.
      b. Incorporate an overall shield.
      c. Have Green jacket.
   2. Category 6 UTP:
      a. Meet or exceed TIA Category 6 performance requirements.

2.3 HORIZONTAL COAXIAL CABLE

A. Manufacturers: CommScope, Belden, Superior Essex.

B. Cables shall be suitable for installation in environment defined and shall meet CATV rating (or permitted substitute as defined by NEC).

C. Station Coaxial Cable shall be RG-6 type, Quad-shield

D. Coaxial cable shall be sweep tested 5 MHz to 2.25 GHz.

E. RG-6 Type (Quad-shield)
   1. Center Conductor: 18 AWG solid bare copper.
   2. Dielectric: Gas expanded (foamed) polyethylene.
   3. First shield: Aluminum-polypropylene-aluminum laminated tape with overlap bonded to dielectric.
   4. Second shield: 34 AWG aluminum braid wire (60% coverage).
   5. Third shield: Non-bonded foil shield.
   6. Fourth shield: 34 AWG aluminum braid wire (60% coverage).
   7. Jacket: Flame retardant PVC. Jacket shall contain carbon black to ensure UV stability
   8. Impedance: 75 ± 3 ohms
   9. Velocity of Propagation: 83% nominal

10. Maximum Attenuation @ 68°F:
    a. 55 MHz: 1.60 dB/100 ft
    b. 750 MHz: 5.65 dB/100 ft
    c. 1 GHz: 6.1 dB/100 ft
    d. Serial 10 Gigabit Ethernet at 850-nm window: 33 m

2.4 COMMUNICATIONS FACEPLATE

A. Manufacturers:
   1. Single-gang: Commscope/ Uniprise
   2. Double-gang: Commscope/ Uniprise
   3. Split grommeted faceplate at monitor locations: Semtron, Midlite, DataPro
   4. Floor box locations:
      a. Coordinate requirements with manufacturer of selected floor box
   5. Audio Visual locations:
      a. Coordinate requirements with manufacturer of selected AV box

B. Modular Jacks and coaxial connectors (if applicable) shall snap into mounting frame, which shall mount into faceplate.
   1. Jacks and connectors may be mounted directly into faceplate.

C. Wall-mount Telephone Faceplate
   1. Faceplates intended to be used in locations where wall mounted telephone set is required shall:
      a. Be stainless steel construction.
      b. Accommodate 1 8-position modular data jack.
         1). Modular jack shall be positioned to mate with wall-mounted telephone.
      c. Mount on standard single gang outlet box.
      d. Include mating lugs for mounting wall-mounted telephone.

D. Work Area Outlet Faceplate
   1. Wall-mounted faceplates intended to be used in general work areas shall:
      a. Accommodate minimum of 4 modular jacks and connectors.
      b. Be a 4 port single gang plate for all outlets requiring 1 to 4 cables. For outlets of 5 or more cables, 9 port double gang faceplates shall be provided.
      c. Be constructed of high impact plastic (except where otherwise noted).
      d. Incorporate recessed designation strips at top and bottom of frame for identifying labels.

1). Designation strips shall be fitted with clear plastic covers.
2). Designation strips and covers shall be positioned over faceplate mounting screws.

2. Power pole faceplates shall incorporate a faceplate extender of sufficient size to accommodate horizontal cable minimum bend radius.
3. Faceplate color shall match other trades.

E. Modular Furniture Outlet Faceplate
1. Confirm opening size with furniture supplier.
2. Coordinate faceplate color with owner.

2.5 4-PAIR MODULAR JACK

A. Manufacturers:
1. Category 6A F/UTP SL Series, Green Icon: Commscope/Uniprise part # 760237683 USL10G-SHLD
2. Category 6 UTP SL Series: Commscope/Uniprise part # 7602376## (## identifies outlet color) USL 600 series

2.6 COAXIAL CONNECTOR/INSERT

A. Manufacturers: Commscope/TE Connectivity part # 1499855-# (# indicates color of insert)

B. Coaxial Connectors shall be threaded male F-type.

C. Male F-connectors shall:
1. Be matched to cable type(s) used.
2. Be single piece connector.
3. Incorporate 1/2" crimp ring using hex crimp.

D. Use female/female feed-through couplings for coaxial outlets and patch panels (if applicable).

PART 3 EXECUTION

3.1 GENERAL

A. Refer to project Drawings for outlet locations.

B. Provide Modular Jacks, Coaxial Connectors (if applicable) and Fiber Optic couplings in faceplates as shown on Project Documents.
1. Provide 1 faceplate per Communications Outlet symbol shown on Project Documents.

C. 4-pair Category-rated horizontal cable length shall not exceed 295 ft measured from horizontal cross-connect and Communications Outlet.

1. Includes slack required for installation and termination.
2. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
3. Any area that cannot be reached within above constraints shall be identified and reported to Engineer prior to installation.
4. Unless otherwise noted, terminate horizontal cabling at IDF room on same floor as outlet.

D. Follow manufacturer's recommended termination practices.

3.2 CABLE INSTALLATION AND TERMINATION

A. General

1. Refer to Section 27-0000 - General Communications Requirements for general cable installation requirements.
2. Total length of 4-pair Category-rated horizontal cable shall not exceed 295-ft.
3. Provide "service slack" for every Horizontal Cable in cable tray
   a. Slack length shall provide 18" of cable slack for accessing rear of faceplate.
   b. Slack shall be installed in an 'S' or 'figure 8' configuration; coiled loops are not allowed.
   c. Total length of 4-pair Category-rated horizontal cable including slack shall not exceed 295 ft.
4. Minimum bend radius shall be 4x cable diameter for F/UTP cable.
5. Minimum bend radius shall be 6x cable diameter for coaxial cable
6. During installation, minimum bend radius shall be ten times outside diameter of F/UTP cables.
7. All Communications cabling shall be in conduit from the wall box to the cable tray.
8. Bundling, tie-wrapping, or lashing of cables not allowed.
9. Cables located within vendor booms shall be:
   a. Provided to the boom by Division 27.
   b. Pulled through the boom by the boom vendor.

c. Tested and terminated by Division 27.

1). Any boom cables failing link testing shall be inspected for jacket and/or cable damage through the boom. If damage is evident, cable shall be replaced via the specified protocol, at no cost to Division 27 or Owner.

B. Horizontal Copper Twisted-Pair Cabling

1. Provide horizontal copper twisted pair cable between horizontal cross connect (typically at IDF Room) and Communications Outlet.

2. At Communications Outlet, terminate each 4-pair Horizontal Cable on 8P8C Modular Jack specified herein.

a. Terminating one cable on more than one jack is not allowed.

b. When applicable, ensure proper bonding of overall shielded is accomplished.

3. At horizontal cross-connect, terminate:

a. For F/UTP cables:

1). Ensure proper bonding of overall shielded is accomplished.

2). Terminate Modular Jack in Patch Panel.

4. Terminate cables using 568B wiring standard.

5. Cable shield and jacket shall be continuous to within 1/2" of termination.

6. Preserve pair twists to point of termination.

7. Refer to Section 27-1100 - Communications Equipment Room Fittings for termination instructions for Modular Patch Panel and Termination Block.

C. Horizontal Coaxial Cable

1. Provide horizontal coaxial cable between Telecommunications Room(s) and coaxial workstation outlets.

2. At Telecommunications Room(s):

a. Terminate each end of cables to F-type connector.

1). Prepare cables per manufacturers recommendations for connector type used.

2). Insure proper center conductor length as specified by manufacturer.

b. Terminate cable to wall-mounted patch panel as specified.

3.3 COMMUNICATIONS OUTLET

A. Faceplates shall be configured to provide connectivity as required by location. Refer to drawings.

B. Mount modular jacks and connectors into faceplates and secure faceplates to outlet box or modular furniture.

C. Allow for minimum 50% future jack growth within each faceplate.

D. Ensure back box space allows for minimum cable bend radii behind each faceplate.

E. Use faceplate extender if required to provide adequate clearance between jack and furniture panel to maintain minimum cable bend radius.

F. Confirm BAS Gateway locations with BAS Contractor prior to beginning work.
   1. Provide one (1) single-jack BAS Gateway outlet for every twelve (12) BAS controllers.
   2. Confirm each outlet location is centered with twelve-controller cluster, to minimize serial cable lengths from the BAS Contractor-provided gateway.

3.4 FIELD TESTING

A. Refer to Section 27-0000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performance of compliance testing.
   1. In addition, refer to sub-sections below for cable type under test.

B. Cabling shall be 100% fault free unless otherwise noted. If any cable is found to be outside specification defined herein, replace that cable and associated termination(s). Then repeat applicable tests.

C. Final test results shall be on installation after jacks are installed in faceplates and faceplates are mounted in final configuration.

D. 4-Pair Horizontal Copper Cable
   1. Test from Jack at Communications Outlet to Patch Panel on which cables are terminated at horizontal cross-connect serving that location.
   2. Testing shall be per TIA/EIA-568 (-B1.1 through -B3.1) Permanent Link test configurations.
   3. Maximum length of station cable shall not exceed 295 feet.
   4. Cables shall be free of shorts within pairs, and be verified for Continuity, Pair Validity and Polarity, and Wire Map (Conductor Position on Modular Jack).
      a. Identify and correct defective, split or mis-positioned pairs.
   5. In addition to above, Performance Testing shall be performed on all cables.
      a. Category 6A F/UTP Cables:
         1). Test to frequency of 500 MHz maximum. Testing of Transmission Performance shall include the following:
            a). Length
            b). Attenuation
            c). Pair to Pair NEXT Loss (new limits)
            d). PSNEXT Loss

e). Return Loss
f). Pair to Pair ELFEXT Loss (Equal Level Far End Cross-talk)
g). PSEFEXT Loss
h). Propagation Delay
i). Delay Skew
j). ANEXT (Alien Near-End Cross-Talk)
k). Alien FEXT
l). PSANEXT
m). PSAELFEXT (PS AARC-F per TIA and SIO)
n). Must pass the link test as directed in ANSI/TIA/EIA 568B.2-10.

6. Test cables to maximum frequency defined by standards covering specified performance category.
7. Perform Transmission Performance Testing using test instrument designed for testing to specified frequencies.
    a. Test records shall verify "PASS" on each cable and display specified parameters - comparing test values with standards based "templates" integral to unit.
8. Nominal Velocity of Propagation (NVP) used for cable type under test shall be traceable to manufacturers' product data.
    a. Test results obtained using an incorrect NVP will be rejected.

E. Horizontal Coax Cable
1. All cables shall be tested using Wire Test Instrument to:
    a. Locate breaks/faults/incorrect terminations
    b. Verify length
    c. Verify impedance
    d. Return Loss (5-MHz to 1-GHz)
    e. Signal strength: Verify signal level at outlet is nominal 10 dBmV +/- 5 dBmV.
2. Terminate cable - as required by individual tests - with its characteristic impedance.

3.5 DOCUMENTATION

A. Refer to Section 27-0000 - General Communications Requirements for general guidelines regarding documentation requirements.

B. Test results shall include record of:
1. test frequencies
2. cable type

3. conductor pair and cable (or Outlet) I.D.
4. measurement direction
5. coaxial signal levels
6. test equipment type, model and serial number
7. date
8. reference setup
9. crew member name(s).

C. Information added by Contractor to Record Drawings relating to Horizontal Cabling shall include cable routes, outlet locations and numbering and other detail necessary to document cable installation.

END OF SECTION

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SECTION 27 5223

NURSE CALL SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for the installation of a Nurse Call-Patient Communication system for University of Kentucky – Neonatal Intensive Care Unit.

1.2 RELATED WORK

A. Section 26 0593 - Electrical Systems Firestopping

B. Section 27 0000 - General Communications Requirements

C. Section 27-0528.29 - Hangers and Supports for Communications Systems

D. Section 27 0528.33 - Raceway and Boxes for Communications Systems

E. Section 27 0528.36 - Cable Trays for Communications Systems

F. Section 27 0553 - Communications Systems Identification

G. Section 27-1000 - Structured Cabling

H. Section 27-1100 - Communications Equipment Room Fittings

I. Section 27 1500 - Communications Horizontal Cabling

1.3 REFERENCES AND STANDARDS

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

B. Refer to Section 27 0000 - General Communications Requirements and 27-1000 **–** Structured Cabling which identify pertinent References and Standards.

C. Other applicable references and standards include:
   1. NEMA SB 10 - Audio Standards for Nurse Call Systems
   2. UL 1069 - Hospital Signaling and Nurse Call Equipment

D. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 WORK BY OWNER

A. Refer to Section 27-0000 - General Communications Requirements and Section 27-1600 – Communications Connecting Cords Devices and Adapters which identifies Work by Owner affecting sub-system(s) covered by this Section.

1.5 SUBMITTALS

A. Provide:
   1. System wiring diagram showing all device locations on system, coordinated with final Vendor (HillRom) drawings

1.6 QUALITY ASSURANCE

A. Refer to Section 27-0000 - General Communications Requirements and 27-1000 – Structured Cabling which identify general quality assurance requirements for the Project.

1.7 GUARANTEE

A. Refer to Division 01, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

PART 2 - PRODUCTS

2.1 SYSTEM 1

A. Active components: Owner Furnished, Contractor Installed (OFCI).

B. Cabling: Contractor Furnished, Contractor Installed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Review vendor drawings, instructions, and requirements before beginning rough-in and cable pull. Box sizes, heights, locations, and conduit connections to be submitted and approved before installation. Bring all discrepancies to Owner and Engineer attention.

B. System installation shall be in accordance with manufacturer's recommendations and requirements.

C. Coordinate all pathway routing with Division 26 and 27 contractors. Coordinate all back box locations with Division 26 and 27 contractors and Architect prior to installation.

D. Division 26 Contractor shall provide all nurse call pathway infrastructure as specified and shown on plans, including back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes. Pathway infrastructure does not include manufactured headwalls.

E. Install complete OFCI Nurse Call-Patient Communication components as shown on drawings.

F. All system components shall be cataloged products of a single supplier.

G. Equipment and wiring shall not be installed until building is enclosed, weather tight, and temperature and humidity conditions are approximately same as final conditions expected.

H. Provide all cabling in conduit and cable tray. Terminate cabling per manufacturers recommendations.
   1. No J-Hooks are allowed.
   2. Refer to drawings for cabling details.

3. Install control board enclosures above accessible ceiling with working clearance for maintenance.

I. Contractor shall coordinate patient control units with items controlled that are not part of the nurse call system, including the following:
   1. TV: Channel selection and volume
   2. Interactive TV: On-Screen Navigation and Menu browsing/selection.
   3. Lights: Up light and/or down light at patient locations

J. At completion of installation, contractor shall provide personnel to check and test the system, subsequently certify to Owner that system is complete, operational, and meets all requirements.
   1. Contractor shall ensure that Owner provided wireless devices are tested and tied into system properly.

K. Label cabling and system components.
   1. For cabling from Nurse Call room board to EIDF room, refer to Section 27 0553 - Communications Systems Identification.
   2. Labeling shall be by mechanical means.
   3. Hand lettered designations are not allowed.
   4. Tags shall be non-removable.
   5. Characters shall be black ink and printed on background of contrasting color.
   6. Labels shall be as large as practicable while fitting properly.
   7. No lettering shall be smaller than 10-point.
   8. Label cables at each end with tag which is wrapped around cable sheath.
   9. Label (stencil) all boxes and enclosures as “NURSE CALL”

L. Test and adjust system to Owner’s satisfaction.
   1. Provide test results to owner.

M. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 SYSTEM DOCUMENTATION

A. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding documentation.

B. Provide one (1) each paper and electronic set of complete instruction manuals which include:
   1. Updated schematics (as built)
   2. Record drawings which depict all station location(s)

3.3 COMMISSIONING

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 28-0000 GENERAL ELECTRONIC SAFETY AND SECURITY REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This section details references, standards, guidelines, requirements and conditions common to all Division 28 work.

B. Work under this Section and related sections are subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.2 DESCRIPTION

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

B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 28 contract documents shall have 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 door or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this contract are connections to equipment provided by contractors. Refer to Architectural, Electrical, and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

G. Where architectural features govern location of work, refer to architectural drawings.

H. All work shall be performed in a "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

I. Division 8 contractor shall be responsible for:

1. Providing all door hardware, both powered and passive.
2. Providing door hardware power supplies, both central/remote and local.

J. Division 28 contractor shall be responsible for:

1. Back boxes and metal raceway systems as described in this document for Security cabling.

K. Division 27 Contractor shall be responsible for backbone and horizontal structured cabling as specified in Division 27.

L. Any cabling sub-contracted or assigned to Division 27 Contractor must be approved by Division 28 Contractor and Construction Manager.

M. Division 28 Contractor shall be responsible for:

1. Participating in coordination of back boxes, conduit, and pull boxes as described in this project scope.
2. Device cabling.
3. Monitoring and control equipment.
4. Connection to and programming of Security Management system to incorporate new readers and alarms and connect to existing system, including coordination with work identified under Section 28 2300.
5. Installation of door position switches in factory-fabricated door and frame penetrations where not provided with door frame.
6. Panic buttons
7. Surveillance devices
8. Terminations & testing
9. Programming and testing added cameras into existing surveillance system per Owner requirements and Section 28 2300.
10. Intercom and door release devices to door hardware power supply.
11. Programming and testing system per Owner requirements and Section 28 5000.
12. Integrating trouble signals from the Pneumatic Tube system via TCP/IP protocol.

1.3 RELATED WORK

A. Related Division 28 Sections include:

1. Section 28 0526 - Grounding and Bonding for Electronic Safety and Security Systems
2. Section 28 1300 - Security Management System
3. Section 28 2300 - Video Surveillance System

B. Related Sections in other divisions of Work:

1. Section 26 0593 - Electrical Systems Firestopping
2. Section 26 0526 - Grounding and Bonding for Electrical Systems
3. Section 26 0533 - Raceways and Boxes for Electrical Systems
4. Section 27 0528.29 - Hangers and Supports for Communications Systems
5. Section 27 0528.36 - Cable Tray for Communications Systems
6. Section 27 1000 - Structured Cabling
7. Section 27 1100 - Communications Equipment Room Fittings
8. Section 27 1300 - Communications Backbone Cabling
9. Section 27 1500 - Communications Horizontal Cabling

C. Continuity of Service:

1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before work is started.
2. When interruption of services is required, Owner shall be notified and shall agree upon a time.

D. Painting:

1. Furnish equipment with factory applied prime finish unless otherwise specified.

2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.

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. Design, cable and component selection, and installation practices shall conform with following:
1. ANSI/NFPA 70-2005, National Electrical Code (2005)
2. Local Electrical Code
3. UL 444 - Communications Cables
4. NFPA 730 - Guide for Premises Security 2006 Edition
5. NFPA 731 – Standard for Installation of Electronic Premises Security Systems 20060 Edition
6. BICSI Electronic Safety and Security Design Reference Manual, First Edition, 2006
7. BICSI Telecommunications Distribution Methods Manual (TDMM)
8. TIA/EIA 568-C.0 through C.3 - Commercial Building Telecommunications Cabling Standard (including applicable Addenda)
9. TIA/EIA 569-B - Commercial Building Standard for Telecommunications Pathways and Spaces.
10. TIA 598-C: Optical Fiber Cable Color Coding.
11. TIA 455-21-A: Mating Durability for Fiber Optic Interconnecting Devices
12. TIA 526-14A: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
13. TIA 526-7: Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant
14. TIA 606: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
15. UL-910: Tests for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air
16. UL-1666: Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
17. Standards identified in individual Technical Sections.
18. State of Kentucky
19. City of Lexington, KY

B. Agencies or publications referenced herein refer to following:
1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials
4. BICSI Building Industry Consulting Services International
5. EIA Electronic Industries Alliance
6. FIPS Federal Information Processing Standards
7. FCC Federal Communications Commission
8. ICEA Insulated Cable Engineers Association
9. IEEE Institute of Electrical and Electronics Engineers
10. NEC National Electrical Code

11. NECA National Electrical Contractors Association
12. NEMA National Electrical Manufacturers Association
13. NESC National Electrical Safety Code
14. NETA National Electrical Testing Association
15. NFPA National Fire Protection Association
16. NIST National Institute of Standards and Technology
17. OSHA Occupational Safety and Health Administration
18. TIA Telecommunications Industry Association
19. UL Underwriters Laboratories, Inc.

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

D. This section specifies a system, or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.6 DEFINITIONS

A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.

1. Entrance facility - an entrance to building for both public and private network service cables
2. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in se documents.
3. Intra-building - within single building.
4. Inter-building - between 2 or more buildings.
5. IP Telephony – Use of Internet Protocol (IP) for two-way transmission of conversations/. Sometimes referred to as “Voice over Internet Protocol (VoIP)”.
6. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1.75" high.
7. Voice over Internet Protocol – See IP Telephony.

B. Typical NEMA Enclosures and Usage

1. Refer to Section 26 0000 – General Electrical Requirements.

1.7 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.

1. AFF Above Finished Floor
2. AWG American Wire Gauge
3. BAS Building Automation Systems
4. BTU British thermal Unit
5. CC Fixed surveillance Camera
6. EC PTZ/Dome surveillance Camera
7. Surveillance Closed-Circuit Television
8. cm centimeters

9.	°C	degrees Celsius
10.	°F	degrees Fahrenheit
11.	DTMF	Dual Tone Multi Frequency
12.	EF	Entrance Facility
13.	ER	Entrance Room
14.	ft	feet
15.	FT	Fiber Transceiver
16.	GbE	Gigabit Ethernet
17.	HC	Horizontal Cross-connect
18.	Hz	Frequency in Hertz (k = kilo, M = Mega, G = Giga)
19.	ID	Inside Diameter
20.	in	inch
21.	IPT	IP Telephony
22.	kg	kilogram
23.	lbs	pounds
24.	LAN	Local Area Network
25.	MC	Main Cross-connect
26.	m	meters
27.	mm	millimeters
28.	Mbps	Megabits per second
29.	µm	micrometer (10^{-6} meter)
30.	OD	Outside Diameter
31.	PBX	Private Branch Exchange (Telephone Switch)
32.	pF	pico-Farad (10^{-12} Farad)
33.	PVC	Polyvinyl Chloride
34.	RU	Rack Unit
35.	sq ft	square feet (area)
36.	VR	Video Receiver
37.	VT	Video Transmitter
38.	WAN	Wide Area Network
39.	WLAN	Wireless Local Area Network
40.	VoIP	Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.8 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.9 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:

1. Refer to Division 1 - Submittal Procedures.
2. Note that for satisfying submittal requirements for Division 28, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 1. However, 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. Mark general catalog sheets and drawings to indicate specific items submitted.
5. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Submittals shall be clearly marked and noted accordingly.
7. Submittals shall be grouped to include complete documentation of related systems, products and accessories in single submittal. Where applicable, dimensions shall be marked in units to match those specified.
8. Submittals shall be in electronic form (ADOBE *Acrobat* PDF) or on paper.
9. Paper documents shall be original catalog sheets or photocopies thereof.
10. Facsimile (fax) sheets will not be accepted.
11. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
12. Include wiring diagrams for electrically powered or controlled equipment.
13. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories, and clearance for maintenance.
14. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
15. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
16. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
17. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 28 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.
18. Unless specifically requested in Division 28 technical sections, submittals of coordination drawings will be returned without review.
19. Submit two-foot section of cable(s) of type(s) to be sent to site for final approval. This two-foot section shall have manufacturer’s cable markings visible. Upon request, samples from every reel sent to site shall be provided.

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 1 - Closeout Procedures.
   2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Owner.
   3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
   4. Manuals shall include following:

a. Copies of shop drawings.

b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.

c. CD ROM's of O&M data with exploded parts lists where available.

d. Phone numbers and addresses of local parts suppliers and service companies.

e. Internet/WEB page addresses where applicable.

f. Wiring diagrams.

g. Start up and shut down procedure.

h. Factory and field test records.

i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section.

5. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.

6. O&M manuals and instructions to Owner shall be provided prior to request for final payment.

D. Record Documents:

1. Refer to General Conditions of Contract, and Division 1 - Closeout Procedures. Prepare complete set of record drawings in accordance with Division 1.

2. Use designated set of prints of contract documents as prepared by Architect to mark-up for record drawing purposes.

1.10 JOB CONDITIONS

A. Building Access:

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

B. Cutting and Patching:

1. Refer to General Conditions of Contract, and Division 1 - 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 only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.

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

C. Housekeeping and Cleanup:

1. Refer to Division 1 - Closeout Procedures.

2. Periodically as work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.11 GUARANTEE

A. Refer to Division 1 for general Guarantee (Warranty) requirements.

B. Refer to technical sections for Guarantee requirement for each system.

1. Where no guarantee requirements are called out, guarantee shall be as called out in Division 1 or for one year after acceptance by Owner, whichever is longer. Guarantee shall cover equipment, materials, and workmanship to be free from defect as called out in Division 1.

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 Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such or contract.

E. Guarantees shall include labor, material, and travel time.

1.12 WORK BY OWNER

A. Refer to individual Sections with this division.

1.13 QUALITY ASSURANCE

A. General:

1. Manufacturers of products covered under this division of work shall be companies specializing in Electronic Safety and Security and Equipment with minimum of 3 years documented experience in producing products similar to those specified herein.

B. Contractor Qualifications:

1. Qualified personnel utilizing state-of--art equipment and techniques shall complete cable and equipment installation and termination.
2. Contractor shall have been in this business for minimum of 3 years.

C. Contractor shall have necessary certifications to provide for Warranty as specified herein.

1. Contractor shall be an active participant in applicable Installers Program(s) operated by Manufacturer(s) of cabling and equipment used.

a. Contractor shall be participant in this program at time of Bidding and remain so throughout project.

D. Refer also to individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications certification requirements.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 1 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

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

B. Examine all drawings and specifications to familiarize themselves with type of construction to be used, and nature and extent of work provided by or trades.

C. Beginning installation means Contractor accepts existing conditions.

D. Verify dimensions and correct locations of hardware before proceeding with installation of hardware, cabling and/or connections.

E. Identify and report to Owner any existing damage to walls, flooring, tiles, and furnishings in work area prior to start of work.

F. Repair all damage caused by cable, raceway, or miscellaneous material to interior surfaces during communication installation.

G. Repairs must match preexisting color and finish of walls, floors, and ceilings.

H. Replace any contractor damaged ceiling tiles to match color, size, style, and texture and shall not be taken from Owner's attic stock.

I. Secure all rooms and offices when not in use.

J. Refer to Division 1 for planned jobsite work hours.

K. Complete installation work using qualified personnel utilizing state-of--art equipment and techniques.

L. Test and document installation upon completion as defined in technical sections.

M. Products selection, installation plans and termination layouts must be reviewed and approved by Owner prior to construction.

N. The review does not exempt Contractor from meeting any of requirements stated in this document.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Contractor shall be responsible for all deliveries of material construction site.

C. Owner will not accept deliveries.

D. Store and protect products under provisions of Division 1

E. For purposes of bidding, assume that Owner will not provide storage facilities for material.
   1. Pending availability, this may be arranged after award.
   2. Include all storage costs in Contract price.

F. Store in clean, dry space.

G. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.

H. Handle in accordance with manufacturer's written instructions.

I. Store cable according to manufacturer's recommendations at a minimum.

J. Store cable in a location protected from vandalism and wear.
   1. If cable is stored outside, cover with opaque plastic or canvas with provision for ventilation to prevent condensation and for protection from wear.

K. Follow manufacturer's storage specifications - in particular, those relating to temperature.

L. Confine all tools, materials and equipment to area designated by Owner.

M. Clean up and dispose of all debris and rubbish resulting from work daily.

N. Clean up of dust, debris, shipping, and packaging material associated with their installation.

O. Provide storage containers as required. Owner's disposal containers shall not to be utilized without written authorization.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors.

B. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted

C. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, sizes of each, opening sizes and sealant products intended for use.

D. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.

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

F. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.

G. Seal non-rated wall openings with urethane caulk.

H. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers, and nuts.

I. Provide chrome or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.4 EQUIPMENT ACCESS

A. Install equipment with ample space allowed for removal, repair, or changes to equipment. Provide ready accessibility to equipment and wiring without moving or equipment, which is to be installed or which is already in place.

B. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 8 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases, or above inaccessible ceilings.

C. Provide necessary coordination and information to Trade Contractor under Division 8 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions, without limitations.

D. Locate security outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

E. Verify room door swings before installing wall-mounted security outlets and install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

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

B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.

C. Do not support equipment or cable pathways from metal roof decking.

3.6 SUPPORT PROTECTION

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

3.7 CLEANING

A. After installation is complete, Contractor shall clean all systems.

B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.

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

3.8 START-UP

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

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

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

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

E. Coordinate start-up with trades.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.9 ACCEPTANCE TESTING

A. Prior to testing, submit in writing to owner (or owners' representative), proposed schedule for acceptance testing.
   1. This notification shall be minimum of (10) working days in advance to allow for participation by Owner.

B. Prior to testing, submit written description of intended test procedures and submit sample test forms to design team.
   1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
   2. Failure to provide above information shall be grounds for design team or Owner to reject any Documentation of related testing and to require repeat of affected test.

C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
   1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.

D. Provide equipment and personnel necessary to conduct acceptance tests.

E. Document all system, sub-system and component tests.

F. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to Owner. Replacement materials shall be new.

G. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

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

I. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.10 OWNER TRAINING

A. System for which training is to be provided shall be complete and fully operational before requesting final acceptance and scheduling system demonstration/training.

B. Provide instruction to owner in proper operation of system, its capabilities and features, and instruction of systems normal in-house maintenance.

C. Operating training shall consist of a course conducted on-site by factory trained professional instructor. Training conducted by installers, technicians or Project Managers is unacceptable.

D. Course content shall include:
   1. System Overview (Topology, Hardware & Cabling)
   2. Programming
   3. Review of Test Results
   4. Review of System Documentation
   5. Review of Labeling Formats
   6. Troubleshooting & Diagnostics
   7. Maintenance
   8. Explanation of Documentation and Test Results

E. Training materials shall consist of following:

1. Formal course outline and agenda
2. Operator training student guide for each student.
3. Hands-on practice with on-line equipment.

F. Training of the owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 79 00, for contractor training requirements. Refer to Section 01 91 00 and the Commissioning Plan for further contractor training requirements.

3.11 DOCUMENTATION

A. Provide project documentation including:
1. Contractor certification of project completion.
2. Record ("As-built") Drawings detailing system wiring and configuration.
3. Results of Acceptance Testing.
4. Manufacturers Operations and Maintenance/Service Manuals for all equipment provided.
5. Copies of technical information communicated via phone, fax, or email.
6. Copies of all approved submittals.
7. Copies of all warranty and service information.

B. Refer also to Technical Sections for requirements specific to covered subsystems.

C. Submit System Documentation in accordance with Division 1 "Project Record Documents".

D. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.

E. Submit documentation within ten (10) working days of completion of installation (including testing) or 3 weeks prior to scheduled occupancy of subject area or scheduled system in-service date, whichever is sooner.
1. Draft drawings may include mark-ups done by hand.
2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.

F. Acceptance Test results shall include description of sub-system tested, equipment/cable/device I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

G. Design team or Owner may request that 10% random re-test be conducted on system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
1. Owner may also perform independent testing to verify results.
2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by design team or Owner, including 100% re-test. This re-test shall be at no additional cost to Owner.
3. Contractor shall provide adequate supervision of owner (or his authorized delegate) shall repeat 100% testing. This re-test shall be at no additional cost to Owner.

H. Drawings shall be CAD generated (AutoCAD 2007 or later) and submitted to design team for review, approval and distribution in hard copy and electronic forms.
1. Each drawing submitted by Contractor as part of Project Documentation shall be identified as an "As-built" drawing and include following (1) Contractor name and/or logo (2) drawing Date.
2. Provide drawings:

a. In Electronic form – Autodesk .DWG format.

1) Provide any specialty fonts used.

b. In Electronic Form – Adobe Acrobat .PDF format (full size plot).

c. Paper copies in reduced size (50%).

3. Numbering and drawing conventions used shall be consistent throughout all documentation provided and comply with established owner standards.

I. Submit Electronic format documents on CD-ROM.

1. Where unique software (or than a MS-Word™ compatible Word Processor or MS-Excel™ spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, (1) licensed copy of such software. Software shall run on an MS-Windows operating system. (Computer and operating system by owner).

J. Provide copies of each install, maintenance, and technical manual supplied with installed products.

K. Documents shall be bound in labeled binders indicating project, system and date.

1. Provide (3) copies. Includes Record documents, manuals, submittal documents, test results as described above.

L. All documentation, including hard copy and electronic forms shall become property of Owner.

END OF SECTION

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SECTION 28-0526 GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section is included for reference only. Refer to Section 26 0526 - Grounding and Bonding for Electrical Systems for product and execution requirements for Electronic Safety and Security Grounding and Bonding for the Project.

1.2 RELATED WORK

A. Related Division 28 Sections include:
   1. Section 28 0000 - General Electronic Safety and Security Requirements
   2. Section 28 1300 - Security Management System
   3. Section 28 2300 - Video Surveillance System

B. Related Sections in other divisions of Work:
   1. Section 26 0593 - Electrical Systems Firestopping
   2. Section 26 0526 - Grounding and Bonding for Electrical Systems
   3. Section 26 0533 - Raceways and Boxes for Electrical Systems
   4. Section 27 1000 - Structured Cabling
   5. Section 27 1100 - Communications Equipment Room Fittings
   6. Section 27 1300 - Communications Backbone Cabling
   7. Section 27 1500 - Communications Horizontal Cabling

PART 2 - PRODUCTS

2.1 Refer to Section 26 0526 - Grounding and Bonding for Electrical Systems

PART 3 - EXECUTION

3.1 Component Bonding

A. Bond metallic system components in IDF and EIDF rooms to existing in-room ground bar per TIA-607-B

END OF SECTION

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SECTION 28-1300 SECURITY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Electronic Access Control and system for project.

B. Work includes furnishing all labor, materials, tools and equipment, and documentation required for a complete and working system as specified in this Section. System shall consist of but not be limited to Controller, Card Readers, Sensors, Switches, Conduit, Boxes, Cable, Protection Devices, and Communication Devices. Programming and cardholder enrolling are also considered as part of installation.

C. Unless noted otherwise, "Contractor" shall refer to Access Control system integrator & installer.

D. Existing UK System: Lenel OnGuard Pro

E. Responsibilities

1. Division 28 contractor shall provide back boxes and metal raceway systems as described in this document for low-vvoltage cabling and for electrical power to each secured location and hardware item.
2. Division 26 Contractor shall provide AC power as required at door, controller and server locations.
3. Division 27 Contractor shall:
    a. Provide backbone and horizontal network cabling.
    b. Furnish system network patch cables.
4. Division 28 contractor shall
    a. Provide device cabling (to EIDF), security devices and monitoring and control equipment as applicable.
        1) Any cabling sub-contracted or assigned to Division 27 Contractor must be approved by Division 28 Contractor.
        2) Any pathways sub-contracted or assigned to Division 26 Contractor must be approved by Division 28 Contractor.
    b. Install patch cables to devices

F. Coordinate with electrical contractor, Video Management System (VMS) design, and door hardware vendor as required to provide a fully functioning system.

G. Applicable provisions of Division 1 shall govern all work under this section.

1.2 RELATED WORK

A. Related Division 28 Sections include:

1. Section 28 0000 - General Electronic Safety and Security Requirements
2. Section 28 0526 - Grounding and Bonding for Electronic Safety and Security Systems

3. Section 28 2300 - Video Management System

B. Related Sections in other divisions of Work:
1. Section 26 0593 - Electrical Systems Firestopping
2. Section 26 0526 - Grounding and Bonding for Electrical Systems
3. Section 26 0533 - Raceways and Boxes for Electrical Systems
4. Section 27 0528.29 - Hangers and Supports for Communications Systems
5. Section 27 1000 - Structured Cabling
6. Section 27 1100 - Communications Equipment Room Fittings
7. Section 27 1300 - Communications Backbone Cabling
8. Section 27 1500 - Communications Horizontal Cabling
9. Section 28 2300 - Video Surveillance System

1.3 REFERENCES AND STANDARDS

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

B. Refer to Section 28 0000 - General Electronic Safety and Security Requirements which identifies References and Standards applicable to all Division 28 work. Other applicable standards are as follows:
1. UL 294 - Access Control System Units.
2. UL 1076 - Proprietary Burglar Alarm Units and Systems.
3. FCC Rules and Regulations Part 15, Radio Frequency Devices
4. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 DEFINITIONS AND ABBREVIATIONS

A. SMS- Security Management System

1.5 WORK BY OWNER

A. Owner shall:
1. Provide list of cardholders for initial SMS programming by Contractor.
2. Provide scheduling of each door, including:
a. Alarm activations and distribution.
b. Door lock and unlock.
c. Cardholder validation by day and time.
d. Delay time of door open alarm.
e. Duration of lock activation upon credential authorization.

1.6 SUBMITTALS

A. Refer to Section 28 0000 - General Electronic Safety and Security Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

1.7 QUALITY ASSURANCE

A. Refer to Section 28 0000 - General Electronic Safety and Security Requirements which identifies general quality assurance requirements for Project.

B. Contractor shall also:
   1. Have successfully completed (2) projects at least 50% magnitude of system specified in following sections.
   2. Be a current Lenel partner in good standing and must have maintained that status for a minimum of three years (concurrent).
   3. UKPD shall oversee start-up, testing and commissioning of all installations.

C. All SMS Lenel OnGuard Pro installations require work to be done by Silver Certified Technicians. All work shall be per manufacturer's recommendations.

D. Contractor shall perform all equipment mounting, cable termination and system programming.

1.8 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 28 0000 – General Electronic Safety and Security Requirements for particular Warranty requirements for Structured Cabling. Those requirements apply to cable and components covered in this section.

PART 2 - PRODUCTS

2.1 NETWORK CENTRALIZED SERVERS

A. General information:
   1. Servers are housed in a virtual server environment in coordination with UK ITS.
   2. SMS requires servers for the administration and control of access control panels across UK.

2.2 GENERAL

A. Security Management System shall provide ability to:
   1. Unlock electrified door locks upon authentication of submitted credential to local card readers.
   2. Monitor door alarms and remotely unlock.
   3. Lock doors on an automated schedule from central system.
   4. Unlock doors as required by code via fire alarm relays.
   5. Annunciate intrusion alarms from remote sensors.
   6. Unlock individual doors manually via operator interface.

2.3 GATEWAYS

A. Refer to specification section 28 2300 for Gateway requirements.

2.4 ACCESS CARD TECHNOLOGY

A. General Information:
1. The Lenel OnGuard Pro system supports the following access card bit formats: HID Corporate 1000 - (University of Kentucky format) The system shall support user-definable custom card bit formats.
2. The system requires HID iCLASS 13.56 MHz credentials.
3. The system supports legacy 125 kHz Proximity credentials and readers; however, no additional legacy 125 proximity readers shall be installed without prior approval from UK Police Department, this includes readers unrelated to access control.

B. Technical Requirements:
1. Card reader shall be compatible with existing card format. The ID Badge may only be procured through UK Wildcard offices.
2. Wildcard must include photo, 125 kHz prox, 13.56 MHz iClass, Mag Stripe, and barcode.

2.5 ACCESS CONTROL HARDWARE

A. The Lenel OnGuard Pro System - Lenel Mercury Controller Panels.
1. SYSTEM CONTROLLER
   a. Model Number: LNL-2220.
   b. Controllers shall include all power supplies, Life Safety FPO250 or Mercury Systems approved equal and Battery units. All parts and pieces needed for a complete UL listed working turnkey system. All controller parts include Lenel Licensing required for UK Campus Enterprise System.

2. MULTI-DOOR DOOR CONTROLLER
   a. Model Number: LNL-1320.
   b. Controller shall accommodate minimum two card readers and associated inputs/outputs.

3. MULTI-INPUT / OUTPUT CONTROLLER
   a. Model Number: LNL-1100 / LNL-1200.
   b. Controller shall accommodate 16 programmable inputs; 2 programmable relay outputs

B. Technical Requirements:
   a. Access Control components must the most current models, with the latest firmware approved and in use by UKPD.

2.6 PROXIMITY CARD READERS

A. Manufacturer: HID
1. Wall-mount: HID Model RP40.
   a. Color: Black

B. General
1. Reader(s) shall:

a. Card readers shall be compatible with existing UK systems. System ssupports the use of Card Readers that read the complete iClass segment information, clear and encrypted, as well as proximity. All-in-one self-contained lock hardware must support all requirements as well.

b. Long-range card readers must be used at all ADA entry doors on all buildings. Reader(s) shall:
   1) Be furnished in Wiegand output model
   2) Be sealed in a polycarbonate enclosure designed to withstand harsh environments.

c. Unless otherwise specified, reader covers shall be furnished in "black" color – cclassic design.

d. Card readers shall recognize iClass 13.56 MHz signals.

e. Contain an indicator to indicate valid and invalid card.

f. Be designed for ambient operating environment.

g. Be powered remotely using centralized power supplies.

h. Read iClass Corporate 1000 sector information.

i. Include Near Field Communication (NFC)/Bluetooth capabilities.

C. Manufacturer: HID

1. Slim Wall-mount: 900NMNTEKEA0NC - RDR, R10, ICLASS, SE E, LF OFF, HF LEG/SIO/SEOS/MA/MIFARE SIO DISABLED, WIEG, TERM, BLK, LED BLUE, FLSH GRN, BZR ON, OPT TAMP, OPEN COLL, CSN SUPPR, IPM OFF, MOBILE-ENABLED-FMT
2. Mullion Mount: 910NMNTEKEA0NC - RDR, R15, ICLASS, SE E, LF OFF, HF LEG/SIO/SEOS/MA/MIFARE SIO DISABLED, WIEG, TERM, BLK, LED BLUE, FLSH GRN, BZR ON, OPT TAMP, OPEN COLL, CSN SUPPR, IPM OFF, MOBILE-ENABLED-FMT
3. Standard
   Wall-mount: 920NMNTEKEA0NC - RDR, R40, ICLASS, SE E, LF OFF, HF LEG/SIO/SEOS/MA/MIFARE SIO DISABLED, WIEG, TERM, BLK, LED BLUE, FLSH GRN, BZR ON, OPT TAMP, OPEN COLL, CSN SUPPR, IPM OFF, MOBILE-ENABLED-FMT

2.7 DOOR CONTACTS

A. General

1. Excluding roll-up doors, door monitoring switches shall be provided by the door hardware trade. The Contractor shall provide end-of-line resistors, and related cable for connection to the nearest ACP.

B. Roll-up door monitoring switches shall be U.L rated and shall be provided as indicated on the drawings and shall be recessed unless otherwise noted. Door contacts shall indicate the position of the associated door, either open, closed, held, short or forced open and shall consist of a sealed assembly designed for either metal or wood frame installation.

C. The Contractor shall supply only magnetic types of door monitoring. Mechanical types of door monitoring shall only be acceptable when used as a tamper switch.

D. Surface mounted contacts: shall be high-security and shall only be used for rolling, overhead or similar door types where recessed mounting is not practical/possible or additional security required.

1. Surface mounted door position switch(s) shall be supplied with armored cabling, properly supported to a junction box above 10', then run open cable back to the nearest ACP.

E. The Contractor shall supply necessary equipment for preventing a voltage surge to prevent damage to any panels or to the device itself.

F. Door contacts shall be a single pole double throw (SPDT) type or multiple switches shall be integrated into the door monitoring switch.

G. End-of-line resistors
1. End-of-line resistor shall be required at the end of the device and shall not be located in the ACP.
2. Excluding tamper switches, each door monitoring switch shall be a logical point unless otherwise noted on the drawings. Grouping multiple doors in series as a single logical point shall not be permissible.
3. Door position switches shall be manufactured by GE or approved equal

2.8 REQUEST-TO-EXIT MOTIONS SENSORS

A. Coordinate with devices provided under Division 8.

B. Manufacturers: GE, Honeywell, or approved equivalent.
1. Provide door header mounted request to exit motion sensors as indicated on Drawings.
2. Minimum Specifications

a. Detection technology	Passive infrared
b. Detection pattern	Narrow beam 35-degree cone
c. Output contact	Normally open contact is closed when sensing zone is entered or exited
d. Power requirements	12 – 24 VDC
e. Mounting	Door header

2.9 CEILING MOUNTED REQUEST-TO-EXIT MOTION SENSORS

A. Coordinate with devices provided under Division 8.

B. Provide ceiling mounted request to exit motion sensors as indicated on Drawings.

C. Minimum Specifications

1. Detection technology	Passive infrared
2. Detection pattern	Narrow beam 35-degree cone

3. Output contact — Normally open contact is closed when sensing zone is entered or exited
4. Power requirements — 12 – 24 VDC
5. Mounting — Ceiling

2.10 DUAL BUTTON HOLD-UP SWITCH

A. Manufacturers: Amseco HUSD-15BMor approved equivalent.
   1. Provide panic buttons as indicated on Drawings.
      a. Power requirements — 12 – 24 VDC
      b. Mounting — Surface; Under-Desk

2.11 DOOR HARDWARE

A. Refer to Division 08

B. All Door Hardware will be equipped with End of Line Resistors if not included with lock hardware. The Lenel OnGuard Pro system features End Line Device Tamper Monitoring.

2.12 POWER SUPPLIES

A. General Information:
   1. Powers supplies for components of the SMS shall be rated and certified for use with the components that they will be powering.

B. Technical Requirements:
   1. Power supplies are required to support Card Reader(s), Door Controller(s), Electrified Door Hardware, Sensor(s) and other components for fully operational turnkey system. Each component connected to power supplies shall be independently fused with rated fuses to match the manufacturer requirements for each specific device.

C. All power supplies are to be hard cabled to their AC power source, via conduit.

2.13 All power supplies cabinets must be equipped with key lock and cabinet tamper switches. BADGE SYSTEM

A. Existing System.

2.14 CABLING

A. General
   1. Cable shall be:
      a. Rated for installed environment.

B. Reader Cable
   1. Construction:
      a. 5 conductor 18 AWG shielded.
      b. Aluminum/Mylar shield with drain wire applied over assembled conductors.

C. Door Lock Power Cable
   1. As required for door hardware. Refer to Architectural Door Schedule and Door Hardware documents.

D. Door Contact/Signal Cable
   1. Door Contact/Signal Cable used for monitoring purposes.
   2. Construction:
      a. 2-conductor 22 AWG twisted, stranded or as recommended by system manufacturer.
      b. Aluminum/Mylar shield with drain wire applied over assembled conductors.

E. Request-to-Exit Motion Detector Signal Cable
   1. Motion Detector Signal Cable used for monitoring purposes.
   2. Construction:
      a. 4-conductor 20 AWG stranded or as recommended by system manufacturer.
      b. Aluminum/Mylar shield with drain wire applied over assembled conductors.
      c. White (natural) Jacketed only.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION COORDINATION

A. Coordinate with Electrical Contractor that:
   1. Adequate pathways are provided and that equipment back boxes are adequate for system installation.
   2. Adequate power has been provided and properly located for security system equipment.
   3. Code-complying fire alarm relays will be installed for cable termination.

B. Coordinate with Door and Door Hardware supplier:
   1. Doors and door frames are properly prepared for electric locking hardware and door position switches are furnished by door type.
   2. Locations of all devices prior to installation.
   3. Electric door power supply locations and connections requirements.
   4. Locations of Remote Release devices.

C. Coordinate with the Communications Contractor:
   1. Locations of all LAN-connected devices and bandwidth requirements.
   2. LAN cable requirements at each device.

D. Coordinate with Intercom Contractor:
   1. Location of all intercom and intercom master station and combination intercom/card reader devices (provided by Intercom Contractor).

2. Wiring requirements of card readers (wiring and terminations provided by Access Control Contractor).

E. At a minimum, coordinate the following with Owner:
1. VLAN/or network partitioning for SMS system.
2. Owner-provided IP addresses for SMS devices.
3. Network infrastructure requirements at SMS gateways.
4. Initial database programming.
5. Planned system down time.
6. Programming and training for new system.

F. Coordinate with Video Management System Contractor, door hardware vendor, and Construction Manager as required to provide a fully functioning Security Management System.

3.2 INSTALLATION

A. General
1. Verify acceptance of each type of specified request-to-exit hardware for each application with local life safety code officials.
2. Verify fail-safe and fail-secure lock requirements with architect.
3. Provide tamper proof fasteners for all equipment in public areas. Fastener finish shall match equipment finish.
4. Maintain minimum three feet of access in front of class 1 electrical equipment.
5. Furnish required installation tools to facilitate cable pulling without damage to cable jacket. Such equipment is to include, but not limited to, sheaves, winches, cable reels, cable reel jacks, pulling tension gauge and similar devices.

B. Delivery, Storage, and Handling
1. Deliver products to and receive products at site under provisions of Division 1, General Requirements (General).
2. Materials shall be stored according to manufacturer's recommendations at minimum.

C. Equipment
1. Provide equipment as indicated on Drawings and specified herein. Additional specific installation requirements are as follows:
2. Door Controllers
   a. Provide Control Panels and Power Supplies in EIDF rooms as shown on Drawings.
   b. Configure security equipment as indicated in Drawings.
   c. Separate 24 VDC and 120 VAC, wire, cable, and devices by 12” minimum space.
   d. Enclose wire and cable in wireways or bundle with wire exiting wireways to terminal strips or panel mounted devices.
   e. Space controllers according to manufacturer’s requirements. Ensure adequate space is allowed for device heat dissipation.
   f. Do not place controller or control devices on enclosure sides.
   g. Do not use any control panel as wire or cable pass-through to adjacent panel.
3. Card Readers

a. Provide card readers and card reader/keypad combination devices as shown on Drawings.

b. Wire card reader LEDs to indicate valid and invalid card reads, and door locked and unlocked conditions. All card reader LED indicators shall operate identically throughout Project. LED shall be red in normal, secured state, and shall be green on valid card read and while door is unlocked.

4. Electric Locking Mechanics

   a. Interface with electric locking mechanics as required by the door hardware.

   b. Provide lock control of electrified locking mechanics through output contacts activated by Door Controller.

5. Electrified Panic and Magnetic Devices

   a. Interface with electrified panic devices as indicated on Drawings. Door hardware to provide all low-voltage wire and connections between SMS power transfer device and electric locking mechanics.

   b. Provide lock control of electrified panic devices through output contacts activated by Door Controller.

6. Door Position Switches

   a. Install as shown on drawings.

   b. Coordinate pathway requirements with Low Voltage Contractor

7. Request-to-Exit Motion Sensors

   a. Refer to Division 8 door hardware schedule for exact locations.

   b. Coordinate pathway requirements with Low Voltage Contractor.

8. Fire Alarm Interface

   a. Connect (hard wire) door controller to building fire alarm system for fail-safe release upon any fire alarm.

   b. Interface with a single low voltage / low current normally closed dry contact from fire alarm system provided by fire alarm Contractor (verify exact locations). Contact shall open on any fire alarm condition.

   c. Provide all additional UL listed fail-safe relays and power supplies necessary to interface to this contact and unlock all fail-safe doors.

   d. Connect fail-safe relays and power supplies to standard building power. Connection of fail-safe devices to emergency or UPS power shall not be acceptable.

9. CABLE INSTALLATION

   a. Visually inspect all wire and cable for faulty insulation prior to installation.

   b. Furnish and install all specified wire and cable as required for functioning SMS system.

   c. Neatly lace, dress and support cabling.

   d. Pull cables in accordance with cable manufacturer's recommendations, University of Kentucky CNS, UK Med Center IT and ANSI/EEE C2 Standards.

      1) Do not exceed manufacturer's recommended pulling tensions.

      2) Do not install bruised, kinked, scored, deformed, or abraded cable.

      3) Do not splice cable between indicated termination, tap, or junction points.

      4) Remove and discard cable where damaged during installation and replace it with new cable.

      5) Pull all cable by hand unless installation conditions require mechanical assistance.

e. Run all wire and cable continuous from device location to final point of termination. No mid-run cable splices shall be allowed.

f. Cables shall not be attached to existing cabling, plumbing or steam piping, ductwork, ceiling supports, or electrical or communications conduit.

g. Cable shall never be laid directly on a ceiling grid or attached in any manner to ceiling grid wires.

h. Furnish and install all cable such that ample slack is supplied at device terminating end of cable to compensate for any final field modifications in camera location.

1) Loosely coil slack in “Figure-eight” in a manner that prevents kinking.

2) Loop radius shall be at least 4X minimum bend radius for cable.

3) Slack length of cable shall be 4 feet (minimum).

i. Provide code-compliant fire proofing techniques for all penetrations of fire rated partitions and slabs, where penetrations are made by or used for installation of VMS System.

j. Coordinate routing of wire and cable requiring isolation from power, radio frequency (RF), electromagnetic interference (EMI), telephone, etc.

k. At no time shall any cable be subjected to a bend less than manufacturer’s specified minimum radius and UK CNS Standards.

l. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on Wire and Cable.

m. Make connections with solder-less devices, mechanically and electrically secured in accordance with manufacturers’ recommendations. Wire nuts shall not be an acceptable means of connecting wire and cable.

D. System Programming and Data Entry

1. Collect all data required to make Security Management System operational. Deliver data to Owner on data entry forms, utilizing data from Contract Documents, Contractor's field surveys and all or pertinent information in Contractor's possession required for complete installation database. Identify and request from Owner any additional data needed to make SMS fully operational and integrated. Completed forms shall be delivered to Owner for review and approval at least 30 days prior to Contractor's scheduled needed date. Contractor will coordinate with University of Kentucky Police Department and Campus Security System Integrator for database and Campus Cloud Services programming and Integration.

2. Provide all initial system programming and setup of SMS including, but not limited to following:

a. Graphical Maps and Icons

1) Coordinate and obtain AutoCAD Architectural backgrounds for implementation as graphical maps. Import all AutoCAD background information provided by Engineer and produce a complete set of graphical maps depicting all SMS points.

b. SMS Card Reader Information

1) Coordinate all card reader values and text, including descriptors, alarm messages, Video camera call up, map call up and identification with Owner.

c. Input and output points for SMS. Coordinate all input and output priorities and text, including descriptors, alarm messages, Video Camera call up, and map call up and identification with design team.

d. Initial system users, including levels of access. This shall include designation of Owner’s representative at "Super User" level immediately upon SMS initialization.

e. Initial Video camera call up and alarm information for interface with VMS system.

f. Program Elevator access per cardholder by cab and floor.

g. Initialize administrator interface to allow owner to update or terminate cardholder privileges and update card information.

E. Furnish and install all non-network SMS wire and cable. Traveling cable for elevator control and LAN/WAN backbone cabling is by others.

F. Provide code-compliant fire proofing techniques for all penetrations of fire rated partitions and slabs, where penetrations are made by or used for installation of SMS.

G. Cable Installation

1. Utilize conduit and/or cable tray to route SMS cables from each door to control panel and power supply. Follow University of Kentucky CNS standards for low voltage cabling.
   a. No A/C current-carrying conductors are allowed in same pathway as signal or low-voltage power cables.
2. Run all wire and cable continuous from device location to final point of termination. Mid-run cable splices shall not be allowed.
3. Wire and cable within enclosures shall be neatly installed, completely terminated, slack minimized and routed in such a way as to allow direct, unimpeded access to equipment within enclosure. All wire and cable shall be bundled and tied. Ties shall be similar to T&B TyRap cable ties.
4. Coordinate routing of wire and cable requiring isolation from power, radio frequency (RF), electromagnetic interference (EMI), telephone, etc.
5. Use of electrical tape for splices and connections shall not be acceptable.
6. Visually inspect all wire and cable for faulty insulation prior to installation.
7. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on Wire and Cable.
8. Make connections with solderless devices, mechanically and electrically secured in accordance with manufacturers' recommendations. Wire nuts shall not be an acceptable means of connecting wire and cable.
9. All system cabling within vertical risers (as required) shall be bundled, wrapped and tied to structure at three meter intervals in order to isolate it from other wire and cable within riser. Additionally, all wire and cable within shaft shall be supported at least every two floors using Greenlee Slack Grips (Split Mesh Lace Closing) or approved equal. Provide all personnel and equipment necessary to install and support cable. All equipment shall be UL listed for application.

H. 120 VAC power dedicated to security and on building UPS and generator backup will be provided by Electrical Contractor for SMS System as indicated on Drawings.

I. Connect to AC power (provided by Electrical Contractor) and provide UL listed power supplies and transformers to distribute low voltage power to system components as required.

J. Provide hinged cover terminal cabinets with tamper switches for all power supplies, transformers and power distribution terminal strips. Provide all conduit and wiring from AC power facilities to terminal cabinets.

K. Provide protection against spikes, surges, noise, and or line problems for all system equipment and components.

L. Protect all exterior, control, power, signal cables and conductors against power surges. Each surge protector shall be UL Listed.

M. In no instance shall any UL labeled door or frame be drilled, cut, penetrated, or modified in any way.

N. Contractor shall be responsible for replacing any labeled door or frame that is modified without written approval from design team.

O. Label all controls as necessary to agree with their function.

P. Label all Wire and Cable in common at both ends using a permanent method such as self-laminating cable marking tape.

1. Tags shall be attached to wire and cable nylon cable ties in an accessible location so that they can easily be read.
    a. Tags shall be installed when wire and cables are installed.
2. Labeling shall be consistent with existing cable labeling system and agree with Record Documentation.

Q. Place wire identification numbers at each end of conductor involved by using sleeve type, heat shrinkable markers. Markers shall be installed so as to be readable from left to right or top to bottom.

R. Mark all connectors with common designations for mating connectors. Connector designations shall be indicated on record drawings.

S. Coil all spare conductors in device back box, panel wireway, or top of panel where wireway is not provided. Conductors shall be neatly bundled and tagged.

3.3 LABELING AND IDENTIFICATION

A. Match all labeling protocols to existing system installation.

1. Cabling, Hardware and Equipment shall be clearly labeled using a Code identifying each piece as unique throughout Video Camera system. This code will aid in identifying hardware for servicing and maintenance.
2. Labels and Tags shall be machine-generated using English character set in black ink on white background labels and Tags.
    a. Self laminating permanent labels are required on cables; permanent non-marring labels are required on all other hardware/cabinets.
    b. No hand-written Labels or Tags shall be allowed.
    c. Dymo or Kroy type adhesive backed lettering is not acceptable.

B. Identify and tag all cables to denote function.

1. Tag shall indicate:
    a. System of which cable is a part,
    b. Indication of cable destination (e.g. room or component), and
    c. Unique alpha-numeric identifier that distinguishes cable from all others in system.

C. All labels shall be machine generated. Handwritten labeling is not acceptable.

D. Label all front panel controls used in normal operation of system using plastic laminate engraved labels, or approved equal.

1. Firmly affix to panel or device.

E. Labeling Formats

1. To be defined by Owner prior to construction.

3.4 SYSTEM START-UP

A. Start-up includes all Contractor-Furnished, Contractor-Installed (CFCI) systems and equipment.

B. Work shall be complete and ready to operate prior to final acceptance.

~~C.~~ All database programming for systems up to inaugural day of beneficial use of Security System, shall be coordinated through UKPD, and UKPD Lenel VAR of Record, Stanley Security. UKPD Lenel VAR of Record is the only authorized group to do SMS programing.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.5 SYSTEM ACCEPTANCE

A. Final acceptance testing of Work will be conducted by design team and Owner.

B. Prior to any final acceptance testing, Contractor shall submit two sets of preliminary (draft) Record Drawings to design team. Preliminary Record Drawings are to be used by design team to conduct system final test. Contractor will also provide completed Programing spread sheets to UKPD for use by Lenel VAR of Record.

~~C.~~ Conduct a complete run test of entire Security System and provide design team with a written report on results of that test. During course of this test, place integrated Security System in service, and calibrate and test all equipment. During SMS portion of test, contractor shall be on site and work in conjunction with Lenel VAR of Record for this testing phase. Contractor shall repair or make changes as needed for all SMS electronic equipment installed by contractor.

D. Following completion of initial run testing and correction of any noted deficiencies, conduct a seven day burn-in test. Intent of burn-in test shall be to prove Security System by placing it in near real operating conditions. During this period Security System shall be fully functional and programmed such that all points, interfaces, controls, reports, messages, prompts, etc. can be exercised and validated. Record and correct any system anomaly, deficiency, or failure noted during this period. Scheduling of final acceptance test shall be based on a review of results of this burn-in test.

E. Deliver a report describing results of functional tests, burn-in tests, diagnostics, calibrations, corrections, and repairs including written certification to design team that installed complete Security System has been calibrated, tested, and is fully functional as specified herein.

F. Prior to final acceptance test, coordinate with Construction Manager for security related construction clean-up and patch work requirements. Security equipment closets and similar areas should be free of accumulation of waste materials or rubbish caused by operations under Contract. At completion of Work, remove all waste materials, rubbish, Contractor's and subcontractors' tools, construction equipment, machinery and all surplus materials.

G. Upon written notification from Contractor that Security System is completely installed, integrated and operational, and burn-in testing completed, design team, Owner's Representative and the UKPD will conduct a final acceptance test of entire system.

H. Contractor to coordinate fee payment with UKPD for the programing services of the Lenel VAR of Record, this fee is based on the information provided in the completed programing spread sheet information. This fee converts the Mercury Panels to be used with Lenel and programs all components into the Campus Lenel On Guard System.

I. During course of final acceptance test by design team, Contractor shall be responsible for demonstrating that without exception, completed and integrated system complies with contract requirements. All physical and functional requirements of project shall be demonstrated and shown. This demonstration will begin by comparing "as built" conditions of Security System to requirements outlined in Specification, item by item. Following Specification compliance review, all Security System head-end equipment will be evaluated.

J. During course of final acceptance test, representatives of UKPD and Owner (UK Health Care) shall test all or random components to their satisfaction as certification of system completion.

K. In order to sufficiently demonstrate Security System's functionality, console operator on duty and his / her superior may be requested to perform certain daily operations inherent to Security System.

1. These operations may include, but not be limited to following:
    a. Manually locking and unlocking of doors within SMS
    b. Verifying status of current alarm / control points within SMS
    c. Verifying and responding to alarms
    d. Generating standard and custom defined SMS reports.
    e. Adding / deleting personnel from card holder database

L. Functionality of all interfaces between systems will be tested.

M. Installation of all field devices will be inspected by design team. This field inspection will weigh heavily on general neatness and quality of installations, complete functionality of each individual device, and mounting, backbox and conduit requirements compliance.

N. All equipment shall be on and fully operational during any and all testing procedures. Provide all personnel, equipment, and supplies necessary to perform all site testing. Provide a minimum of two employees familiar with system for final acceptance test. One employee shall be responsible for monitoring and verifying alarms while or will be required to demonstrate function of each device. Supply at least two two-way radios for use during test. A manufacturer's representative may be present on site to answer any questions that may be beyond technical capability of Contractor's employees, if Contractor so elects or by specific request of design team or Owner, at no charge to design team or Owner.

O. Upon successful completion of final acceptance test (or subsequent punch list retest) design team will issue a letter of final acceptance.

P. design team retains right to suspend and / or terminate testing at any time when system fails to perform as specified. In event that it becomes necessary to suspend test, all of Owner's / design team fees and expenses related to suspended test will be deducted from Contractor's retainage. Furthermore, in event it becomes necessary to suspend test, Contractor shall work diligently to complete / repair all outstanding items to condition specified in Specification and as indicated on Drawings. Contractor shall supply design team with a detailed completion schedule outlining phase by phase completion dates and a tentative date for a subsequent punch list retest. During final acceptance test, no adjustments, repairs or modifications to system will be conducted without permission of design team.

Q. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.6 DOCUMENTATION

A. Refer to Section 28 0000 – General Electronic Safety and Security Requirements for requirements relating to Documentation for all Division 28 work.

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SECTION 28-2300 VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for the Video Management and Surveillance System for the project.

B. Work includes furnishing all labor, materials, tools and equipment, and documentation required for a complete and working system as specified in this Section. System shall consist of but not be limited to Cameras, Gateway Appliances, Boxes, Wire, Protection Devices, and Communication Devices. Programming is also considered as part of installation.

C. Responsibilities

1. Division 28 contractor shall provide back boxes and metal raceway systems as described in this document for low-Voltage cabling and for electrical power to each secured location and hardware item.
2. Division 26 Contractor shall provide AC power as required at door, controller and server locations.
3. Division 27 Contractor shall:
    a. Provide backbone and horizontal network cabling.
    b. Furnish system patch cables.
4. Division 28 contractor shall
    a. Provide device cabling (to zone enclosure), security devices and monitoring and control equipment as applicable.
        1) Any cabling sub-contracted or assigned to Division 27 Contractor must be approved by Division 28 Contractor.
        2) Any pathways sub-contracted or assigned to Division 26 Contractor must be approved by Division 28 Contractor.
    b. Install patch cables to devices.

D. Coordinate with Access Control and Intrusion Detection system contractor as required to provide a fully functioning system.

E. Unless noted otherwise, "Contractor" shall refer to security system integrator & installer.

F. Applicable provisions of Division 1 shall govern all work under this section.

G. Video surveillance can be restricted or prohibited by law. This document details technical considerations only. It is assumed that registration, licensing, policies regarding disclosure and privacy (notification, processing of images, time and date stamping, recording of sound, etc.), and or legal obligations are responsibility of Owner.

1.2 RELATED WORK

A. Related Division 28 Sections include:

1. Section 28 2000 - General Electronic Safety and Security Requirements
2. Section 28 0526 - Grounding and Bonding for Electronic Safety and Security Systems
3. Section 28 1300 - Security Management System

B. Related Sections in other divisions of Work:

1. Section 26 0593 - Electrical Systems Firestopping
2. Section 26 0526 - Grounding and Bonding for Electrical Systems
3. Section 27 0528.29 - Hangers and Supports for Communications Systems
4. Section 26 0533 - Raceways and Boxes for Electrical Systems
5. Section 27 0528.29 - Hangers and Supports for Communications Systems
6. Section 27 1000 - Structured Cabling
7. Section 27 1100 - Communications Equipment Room Fittings
8. Section 27 1300 - Communications Backbone Cabling
9. Section 27 1500 - Communications Horizontal Cabling
10. Section 28 1300 - Security Management System

1.3 REFERENCES AND STANDARDS

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

B. All work and materials shall conform in every detail to rules and requirements of National Fire Protection Association, Kentucky Electrical Code, Lexington, KY building codes, and current manufacturing standards.

C. All materials shall be listed by UL and shall bear UL label. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label entire system shall be so labeled.

D. Other applicable standards are as follows:

1. ANSI/IEEE C2 - National Electrical Safety Code
2. NFPA 70-1999 - National Electrical Code
3. IEEE/ANSI 142-1982 – Recommendations for Grounding of Industrial & Commercial Power Systems.
4. NTSC/EIA RS-170A Video Standard
5. IEEE 802.3 standards for CSMA/CD (Ethernet) based LANs
6. Emissions: FCC 15, Class A; CE: EN55022 (Emissions)
7. CE: EN50082-01 (Immunity)
8. CE, UL 1950; CUL 1950 CE: EN60950 (Safety)
9. State of Kentucky
10. City of Lexington, KY

E. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.4 DEFINITIONS AND ABBREVIATIONS

A. Refer to Section 28 0000 – General Electronic Safety and Security Requirements which identifies general definitions and abbreviations applicable to all Division 28 sections.

B. In addition:

1. VMS – Video Management System
2. LAN – Local Area Network

1.5 WORK BY OWNER

A. Owner shall provide:
   1. Identifying exact security device mounting locations.
   2. Acceptable per-camera field-of-view information.
   3. Enterprise-wide Data Network / LAN to be utilized by VMS system.
   4. Cross-connections from VMS to building LAN.
   5. All active LAN components (switches, routers) as required for system function.
   6. IP-address allotment and management for VMS devices as needed.

1.6 SUBMITTALS

A. Refer to Section 28 0000 - General Electronic Safety and Security Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

1.7 QUALITY ASSURANCE

A. Refer to Section 28 0000 - General Electronic Safety and Security Requirements identifies general quality assurance requirements for the Project.

B. Video Surveillance System Contractor shall:
   1. Have successfully completed (2) projects at least 50% in magnitude of system specified in following sections.
   2. Be fully certified by Salient for Sales and Installation of Salient equipment.

1.8 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 28 0000 - General Electronic Safety and Security Requirements for particular Warranty requirements this system. Those requirements apply to all components covered in this section.

PART 2 - PRODUCTS

2.1 NETWORK CENTRALIZED SERVERS

A. General information:
   1. VMS requires a management server in addition to recording servers. The number of recording servers is based on the number of video streams or channels that are being recorded. System administrators monitor server health and capacity adding additional servers and resources as new video streams or cameras are added to the system.

2.2 GENERAL

A. VMS system shall deliver quality, color video over an UTP structured cable system using minimum H.264/5 compression and shall provide for monitoring and recording of all cameras in system as indicated herein and on project Drawings.

B. Video shall be viewable and configurable from a workstation on network using standard Browser software.

2.3 SURVEILLANCE CAMERA (FIXED)

A. Acceptable Manufacturer:, Axis, Sony, Panasonic or any Salient Supported camera. Camera shall:

1. Be ceiling-mountable dome-type.
2. Be IP-native.
3. Use a high-quality IR-sensitive progressive scan megapixel sensor.
4. Utilize Power-over-Ethernet (PoE) for device power.
5. Provide video streams in HDTV 1080p (1920x1080) at 30 frames-per-second (fps) using minimum H.264 codec.
6. Be equipped with Day/Night functionality, Wide Dynamic Range (WDR) color video to 1/2 lux, black and white below 1/2 lux and feature remote back focus capabilities.
7. Be provided complete with standard interior (3-9 mm nominal) auto-iris lens.
   a. Per-camera lens selection dependent upon Owner-required field-of-view.
8. Have a smoked bubble.
9. Have housing and mount color to match surrounding architectural colors.
10. All cameras submitted must be certified compatible with or obtain approval from Salient Systems and be approved by UKPD prior to bidding.
11. All cameras shall be tamper proof and located to minimize vandalism.
12. Cameras are required to have the most current approved firmware compatible with Salient Systems. The use of POE and Wireless locks must be minimal and requires UKPD approval during design.

2.4 VIDEO MANAGEMENT SYSTEM GATEWAY APPLIANCE

A. Recording servers are centrally located and maintained by UK ITS.

B. New camera installation shall be coordinated with UKPD and Stanley Security Group to ensure capacity for recording is added for when needed.

C. Camera information shall be provided to UKPD and Stanley Security Group for adding to the system and programming. See Programming Sheet in 2800000S04- ELECTRONIC SAFETY & SECURITY – Security System Standard. Link: https://www.uky.edu/cpmd/design-standards/divisions-20---29---facility-services-subgroup#design_standards-page-6

D. Acceptable Manufacturer: Salient

1. VMS Gateway shall be compatible with existing UK Salient system.
   a. Rack-mounted
   b. 8TB On board Storage Video Storage. Confirm with UK IT prior to purchase.
   c. Provide proper quantity of Gateways to accommodate the number of cameras needed for the project with a minimum of (1) Gateway for 5th floor. Provide capacity for 50% future IP interior cameras.

2.5 WIRE AND CABLE

A. General
   1. Install Division 27-furnished device patch cables.
   2. Provide all interconnecting system cabling at head-end.
   3. Confirm and provide any necessary interface cabling with existing Access Control system.

PART 3 - EXECUTION

3.1 GENERAL

A. Work performed for installation of VMS system shall be performed by Security System Integrator – "Contractor". Equipment installer and manufacturer shall inspect all conditions and system proposed installations before proceeding. No work shall be started or equipment procured until all conditions are satisfactory to manufacturer, and Owner's representative.

B. Provide equipment as indicated on Drawings and specified herein.

C. Provide all labor and materials necessary to construct systems as described herein to include furnishing and installing all system equipment, interconnecting cabling, programming and start-up, software (including software upgrades and reprogramming as necessary), termination components, mounting hardware, incidentals, accessories, testing, labeling, documentation and training as detailed in following sections.
   1. Neatly lace, dress and support cabling.
   2. Coordinate any downtime with Owner.

D. Prior to installation, confirm:
   1. Conduit and equipment back boxes are as required.
   2. 120V AC Power is as required and is properly located.
   3. LAN structured cabling is as required and properly located.
   4. Locations of all devices prior to installation.
   5. Final camera locations, Owner-desired views, and camera housing and mount requirements with Owner prior to installation.
   6. Camera housing and mount finishes with Architect and Owner.

E. Install and wire equipment in accordance with University of Kentucky CNS Standards manufacturer's recommendations, and accepted engineering and installation practices.

F. Mount system components as recommended by manufacturer.

G. All equipment mounting in communications closets must be approved by with UK CNS prior to installation.
   1. Arrange equipment to facilitate permanent access for use and maintenance.

3.2 CABLE INSTALLATION

A. Neatly lace, dress and support cabling.

B. Pull cables in accordance with cable manufacturer's recommendations and ANSI/EEE C2 Standards as well as UK CNS Standards.
   1. Do not exceed manufacturer's recommended pulling tensions.
   2. Do not install bruised, kinked, scored, deformed, or abraded cable.

3. Do not splice cable between indicated termination, tap, or junction points.
4. Remove and discard cable where damaged during installation and replace it with new cable.
5. Pull all cable by hand unless installation conditions require mechanical assistance.

C. Run all wire and cable continuous from device location to final point of termination. No mid-run cable splices shall be allowed.

D. Furnish and install all cable such that ample slack is supplied at device terminating end of cable to compensate for any final field modifications in camera location.
1. Loosely coil slack in "Figure-eight" in a manner that prevents kinking.
2. Loop radius shall be at least 4X minimum bend radius for cable.
3. Slack length of cable shall be 4 feet (minimum).

E. Provide code compliant fire proofing techniques for all penetrations of fire rated partitions and slabs, where penetrations are made by or used for installation of surveillance System.

F. Coordinate routing of wire and cable requiring isolation from power, radio frequency (RF), electromagnetic interference (EMI), telephone, etc. with design team.

G. At no time shall any cable be subjected to a bend less than manufacturer's specified minimum radius. Refer also to UK CNS Standards.

H. Provide grommets and strain relief material where necessary to avoid abrasion of wire and excess tension on Wire and Cable.

I. Make connections with solder-less devices, mechanically and electrically secured in accordance with manufacturers' recommendations. Wire nuts shall not be an acceptable means of connecting wire and cable.

3.3 IP VIDEO CAMERAS

A. Locate Video Cameras per project drawings.

B. Field-verify exact locations and field-of-views with Owner prior to installation.

C. Provide Video camera lenses to accommodate Owner-coordinated field-of-view per camera.
1. Field verify and confirm views with Owner prior to procurement and final installation and adjust camera positions and lens sizes as required upon installation.

D. Configure resolution, frame rate, password, etc. to match existing system installation.

E. Coordinate with Owner prior to installation to confirm required parameters.

F. Wire interface(s) to external alarms (as applicable).

3.4 NETWORK CONNECTION

A. Cross-connections to building LAN by Owner. No equipment may be connected to UK networks by any Sub-Contractor, only by UK CNS or UK Med Center IT.

3.5 LABELING AND IDENTIFICATION

A. Match all labeling protocols to existing system installation.

1. Cabling, Hardware and Equipment shall be clearly labeled using a Code identifying each piece as unique throughout Video Camera system. This code will aid in identifying hardware for servicing and maintenance.
2. Labels and Tags shall be machine-generated using English character set in black ink on white background labels and Tags.
    a. Self laminating permanent labels are required on cables; permanent non-marring labels are required on all other hardware/cabinets.
    b. No hand-written Labels or Tags shall be allowed.
    c. Dymo or Kroy type adhesive backed lettering is not acceptable.

B. Identify and tag all cables to denote function.
1. Tag shall indicate:
    a. System of which cable is a part,
    b. Indication of cable destination (e.g. room or component), and
    c. Unique alpha-numeric identifier that distinguishes cable from all others in system.

C. All labels shall be machine generated. Handwritten labeling is not acceptable.

D. Label all front panel controls used in normal operation of system using plastic laminate engraved labels, or approved equal.
1. Firmly affix to panel or device.

E. Labeling Formats
1. To be defined by Owner prior to construction.

3.6 SYSTEM TESTING AND ACCEPTANCE

A. System shall be complete and fully operational before requesting final acceptance and scheduling system integration into the Campus Cloud Services. This integration is coordinated through University of Kentucky Police Department.

B. Installation of all field devices will be inspected by Owner or Owner's representative. Inspection will consider overall neatness and quality of installation, functionality of each individual device, mounting, wiring and labeling.

C. Conduct a seven day burn-in test. Intent of burn-in test shall be to prove System by placing it in near real operating conditions, prior to connection to Campus Cloud Services. .
1. During this period System shall be fully functional and programmed so that all points, controls, messages, prompts, etc. can be exercised and validated.

D. Provide written notification to Owner that system is completely installed, integrated, burn-in testing completed and is fully functional as specified herein.
1. Submit schedule for acceptance testing. Representatives of Owner, UKPD and/or Design team may witness test procedures.
2. Notify Owner, UKPD and Design team in writing a minimum of two weeks in advance to allow for such participation.
3. Describe test procedures prior to testing and submit sample test form to Design team.

E. Prior to final acceptance test, equipment rooms and similar areas should be free of accumulation of waste materials or rubbish caused by operations under Contract.

F. Equipment shall be on and fully operational during any and all testing procedures.

1. Provide all personnel, equipment, and supplies necessary to perform site testing.
2. Supply at least two two-way radios for use during test.
3. A manufacturer's representative shall be present on site to answer any questions that may be beyond technical capability of Contractor's employees, if Contractor so elects or by specific request of Design team or Owner, at no charge to Design team or Owner.

G. During course of final acceptance test, Contractor shall be responsible for demonstrating that, without exception, provided VMS system complies with contract requirements.

H. Testing shall include but not be limited to:
1. Continuity and conductor/connector integrity on all cables.
2. Demonstrate functionality of all cameras including:
a. Owner-acceptable field of view.
b. Response to alarms.
c. Response to Access Control System inputs.
3. Confirm remote viewing, configuration and camera control via Browser.
a. Confirm system rights settings for authorized users.
4. Demonstrate storage and retrieval of recorded video by date/time.

I. Owner and/or Design team retains right to suspend and/or terminate testing at any time when system fails to perform as specified.
1. In event it becomes necessary to suspend test, Contractor shall work diligently to complete / repair all outstanding items to condition specified in Specification and as indicated on Security Drawings.
2. All of Owner's / Design team fees and expenses related to suspended test will be deducted from Contractor's retainage.
3. Contractor shall supply Owner with a detailed completion schedule outlining phase by phase completion dates and a tentative date for a subsequent punch list retest.
4. During final acceptance test, no adjustments, repairs or modifications to system will be conducted without permission of Design team.

J. Upon successful completion of final acceptance test (or subsequent punch list retest) Design team will issue a letter of final acceptance.

K. Records of Test Results shall be included in System Documentation and submitted as detailed below.

L. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

M. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.7 DOCUMENTATION

A. Refer to Section 28 0000 – General Electronic Safety and Security Requirements for requirements relating to Documentation for all Division 28 work.

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SECTION 28-3116 MULTIPLEXED FIRE DETECTION AND ALARM SYSTEMS

PART 1 GENERAL

1.1 RELATED WORK

A. Section 21-1314 - Automatic Fire Sprinkler System

B. Section 21-1318 - Fire Protection Systems

C. Section 23-0993 - Control Sequences

D. Section 26-0000 - General Electrical Requirements

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

F. Section 26-0526 - Grounding and Bonding for Electrical Systems

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

H. Section 26-0553 - Electrical Systems Identification

1.2 REFERENCE

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

1.3 DESCRIPTION

A. In general work consists of:

1. Furnish and install complete Multiplexed Fire Alarm System as shown on plans.
2. Connecting new fire alarm devices to existing building Honeywell Notifier Fire Alarm system.
3. System shall:
    a. Be interfaced with and report to existing building Honeywell Notifier Fire Alarm system in an identical manner as existing devices throughout the building.
    b. Be an intelligent analog system.
    c. Allow for loading and editing special instructions and operating sequences as required.
    d. Be capable of on-site programming to accommodate system expansion and facilitate changes in operation.
    e. Be wired, connected, and left in operating condition.
4. System includes:
    a. Manual Stations
    b. Heat Detectors
    c. Smoke Detectors
    d. Alarm Indicating Devices
    e. Terminations

f. Other necessary material for complete operating systems.

5. 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.

6. Existing NAC panels are located in existing EIDF rooms on first level. Provide additional NAC panels as required to provide a fully functioning fire alarm system within area of work.

1.4 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 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

1.5 QUALIFICATIONS

A. Equipment shall be supplied by company specializing in fire alarm and smoke detection systems with 5 years documented experience

B. Work shall be performed by licensed contractor regularly engaged in installation and servicing of fire alarm systems.

C. Proof of 5 years documented experience and factory authorization to furnish and install equipment proposed shall be furnished.

D. Contractor shall be located within 100 miles or less from site of project.

E. Programming of existing building Honeywell Notifier Fire Alarm system shall be performed by a technician certified by Honeywell Notifier in order to maintain the UL listing of existing building fire alarm system, and to extend the UL listing of the overall fire alarm system to the new devices installed under this scope of work.

1.6 SUBMITTALS

A. Bill of materials listing part number and quantity of components and devices.

B. Block diagrams showing layout and operation of entire system.

C. Schematic diagrams, of circuits from field devices to terminal strip(s) associated with existing 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.

D. Standby battery power calculations.

E. Sound amplifier and strobe power supply calculations showing current draws for every device and module during standby, alarm and trouble conditions.

F. Voltage drop calculations for both initiating and alarming circuits.

G. List of device addresses with location labeling as they will appear in 2 line, 40 character display of fire alarm panel and remote annunciator.

H. Submission 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 (DEVICES ONLY)

A. Honeywell Building Systems

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 match current building sequence of operation for system initiation, including:
    a. Appropriate initiating device circuit red LED shall flash on Control Panel and remote annunciator until the alarm has been acknowledged at Control Panel or remote annunciator.
    b. Once acknowledged, this same LED shall latch on.
    c. Subsequent alarm received after acknowledging shall flash subsequent zone alarm LED on Control Panel and remote annunciator**.**
    d. Acknowledgment of alarm shall not reset activated device.
    e. Pulsing alarm tone shall occur within Control Panel and remote annunciator until event has been acknowledged.
    f. Alarm audible-indicating devices shall sound in three pulse temporal pattern until silenced by alarm silence switch at Control Panel or remote annunciator.
    g. Visual alarm indicating devices shall operate in continuous flashing pattern until system is reset.
    h. Signal to notify the local fire department supervising station shall be activated.
    i. Doors held open by door control devices shall close.
    j. Mechanical controls shall activate air handling systems as specified by Division 23.
2. 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

3. Fire alarm system provided for this project must have the ability to communicate directly with the existing building Honeywell Notifier fire alarm system. All required programming and equipment needed to perform these tasks shall be included under this scope of work.

B. Silencing

1. Alarm audible indicating devices shall be silenced by operating alarm silence switch or by use of key operated switch at remote annunciator.

2. Strobes shall remain active until system is reset.

3. Subsequent zone alarm shall reactivate alarm signals.

C. Reset

1. SYSTEM RESET button shall return system to its normal state after an alarm condition has been remedied.

D. Supervision

1. System shall independently supervise:

   a. Initiating device circuits.

   b. Independently fused indicating appliance circuits for alarm horn/strobe units.

   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 and remote annunciator. 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.

2. Device activation shall be annunciated at Control Panel and remote annunciator.

3. Independently supervised circuits shall include visible amber "Trouble" LED to indicate disarrangement conditions per circuit.

4. Disarrangement conditions of any circuit shall not affect operation of other circuits.

5. Alarm activation of any initiation circuit shall not prevent subsequent alarm operation of any other initiation circuit.

6. System shall have provisions for disabling and enabling circuits individually for maintenance or testing purposes.

E. Power Requirements

1. Provide 120 VAC power via dedicated branch circuit in emergency panel.
2. Branch circuit shall have "breaker lock" to prevent accidentally de-energizing of power to fire alarm panel.
3. Circuit breaker shall be painted red and labeled "FIRE ALARM".
4. Provide back-up battery capacity to operate entire system in normal supervisory mode for period of 24 hours with 10 minutes of alarm operation at end of period.
5. System shall automatically transfer to standby batteries upon power failure.
    a. Battery charging and recharging operations shall be automatic.
6. 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 hours.
        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 24VDC for peripheral devices requiring ± 5% regulation and 8 amps at 24VDC for standard peripheral devices.
        6) Be compatible with lead acid batteries.
7. External circuits requiring system operating power shall be 24VDC and shall be individually supervised and fused at Control Panel.

F. Smoke Detection Operation

1. New smoke detectors shall report to existing Honeywell Notifier fire alarm panel in an identical manner to existing building smoke detectors.
2. Smoke detector alarms shall be processed and reported immediately.
3. Upon building completion, alarm verification shall be added to detector(s) as directed by project engineer.
4. 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.
5. System shall maintain constant smoke obscuration sensitivity for each detector by compensating for environmental factors.
6. 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.

7. 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.
8. For scheduling of maintenance, Control Panel shall generate MESSAGE indication for any detector approaching trouble condition due to dirt or contamination.
9. 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.)
10. Values at Control Panel shall be in "percent of smoke obscuration" format so that, no interpretation is required by operator.
11. 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
12. It shall be possible to program Control Panel to automatically change sensitivity settings of each detector based on time-of-day and day-of-week. There shall be 3 sensitivity settings available for each detector.

G. System Response

1. Maximum elapsed time from sensing fire at non-smoke detector initiating device or second smoke detector until it is recorded at Control Panel and remote annunciator shall not exceed 5 seconds and not to exceed 15 seconds for remote station reporting.
2. Maximum elapsed time for first smoke detector shall not exceed 35 seconds including verification period and not to exceed 40 seconds for remote station reporting.

H. Air Handling Unit System Operation/Interface

1. Control Panel shall provide alarm interface to air handling/energy management system controllers, which shall perform automatic functions as specified in Division 23.
2. Fire Alarm Control Panel shall provide manual control mode to override fire alarm panel's signal so that air handling units can be restarted.

I. 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.

J. One-Way Voice Communications

1. 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. Eighth floor shall be a separate selectable zone.

2. All Call:

a. Upon activation of "All Call" switch, 2 seconds of tone shall sound over all speakers in system. At end of this tone, the operator shall be able to make announcements via push-to-talk paging microphone over all system speakers.

b. Strobes shall flash in all areas or floors.

c. System shall default to normal operations if the microphone becomes inactive for more than 1 minute.

K. 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. Attempting to use another phone on same circuit shall not cause pulsing tone to activate if any two-way communications are already established.

c. Any new circuits activated shall cause their discrete phone circuit LEDs to flash until acknowledged.

d. Two-Way Communications System shall provide capacity to handle simultaneous use of multiple remote phones.

e. 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.

f. 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.

g. When combined with 1-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.

h. 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.

2.4 ACKNOWLEDGMENT

A. Incorporate new area of work into the existing fire alarm system acknowledgement programming.

B. 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.

C. 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.

D. Pressing appropriate acknowledge button shall acknowledge all points

2.5 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.

2.6 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 a Honeywell Notifier certified technician at no charge until system is accepted by Owner.

E. Existing Owner Tridium graphical dashboard shall be updated to reflect devices installed in this scope of work, and shall communicate information as indicated on fire alarm control panel. Provide programming at fire alarm control panel required to communicate information of new devices and coordinate with Tridium programmer and Owner.

F. Fire alarm system shall be programmed in order to allow voice override of announcements on the floor of alarm from existing Medical Center Physical Plant Division dispatch office located in the Chandler Pavilion H.

2.7 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.

2.8 TWO-WAY VOICE COMMUNICATION SYSTEM

A. Two-way voice communications shall be integral with the fire alarm system.

B. All wires between Central Control and remote units shall be supervised. Any fault shall be reported visually and audibly at Central Control.

C. Line (talk) circuit modules shall be furnished to supervise for shorts, opens and grounds of circuit wiring.

D. Each line module shall contain "Call" and "Trouble" indication and, 2-position switch to enable two-way voice communication between remote and master phones.

E. Provide Emergency Phone Jacks as shown on plans.

1. Jack shall be mounted on stainless steel single gang plate with words "Fire Emergency Phone" screened on each.

F. Provide Remote Phones in break rod cabinets, where shown on plans.

G. Emergency phones shall be constructed of red cyclac type t, thermal ABS material and be equipped with armored cable.

2.9 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 2 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), which shall 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 24VDC 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 shall:
    a. Be 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. Be covered with plastic bags after installation to maintain cleanliness. Bags shall be red for quick visual identification for removal at time of occupancy.

F. Intelligent Photoelectric Smoke Detectors

1. Detectors shall:
    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 shall:
    a. Be combination rate-of-rise and fixed temperature (135°F unless noted).
    b. Sense within temperature range of 32°F to 158°F. Control panel shall be capable of sensing either set point of 135°F, or rate-of-rise of 15°F per minute for fire sensing.

H. Intelligent Duct Smoke Detectors

1. Duct detectors shall be of photoelectric ionization type.
2. Detectors shall be rated for air velocity to be expected.
3. It shall be possible to alarm duct detector by using remote or local test switch.
4. It shall be possible to clean sampling tubes by access through duct housings front cover.
5. Provide relays adjacent to motor controller, and remote keyed test switch and alarm LED indicator.
6. In mechanical rooms, alarm LED indicators shall be grouped on a stainless steel cover plate.
    a. Mount adjacent to main mechanical room door.
    b. Each LED shall be labeled with detectors loop and address.
    c. Floor plan of room showing detectors and addresses shall be located adjacent to cover plate.
    d. Provide Plexiglas cover over plan.

I. Manual Stations

1. Manual stations shall:
    a. Be double action.
    b. Be 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 2 wires.
    d. Mechanically latch upon operation and remain so until manually reset. Stations, which use Allen wrenches or special tools to reset shall not be accepted.

e. Be fitted with screw terminals for field wire attachment.

2. Address shall be field programmable on station.

J. Interface Modules - General

1. Interface Modules shall:

a. Receive 24VDC power from separate two wire circuit.

b. Be available in either Class B or Class A supervision version.

c. Be supervised and identified by Control Panel.

d. Be capable of being programmed for its "address" location.

e. Be 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 shall:

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 shall:

a. Be 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.

2.10 SPEAKER/STROBE DEVICES

A. Combination Speaker/Strobe Devices

1. Speakers:
    a. Operate on 24V 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 feet using 1-watt tap.
    f. Speakers located in mechanical room shall have 3 taps minimum with 8W being the highest.
    g. Provide minimum sound pressure level of 90 dBA at 10 feet using 2-watt tap.
    h. Include 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 110cd.
    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 180° field of view.
4. Have off-white semi flush housing.
5. Strobe circuit loading shall be calculated at 75cd 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 shall have:
    a. 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.

2.11 CONVENTIONAL PERIPHERAL DEVICES

A. Door Holders

1. Magnetic door holders shall:
    a. Be provided by the Trade Contractor. Refer to Section 08 7110 - Door Hardware.

b. Be capable of being surface, flush, or semi-flush mounted as required.

2. Power for door holders shall be 24 volt.

B. Fault Isolator Module

1. Provide Fault Isolator Module (FIM) on initiating device circuits in following situations:

a. 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.

PART 3 EXECUTION

3.1 GENERAL

A. Class A 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.

3.3 CONDUCTORS

A. Cables and wires shall be provided per manufacturer shop drawings.

B. Conductors shall be color-coded. Coding shall be consistent through out facility.

C. Green wire shall be used only for equipment ground.

D. Cable Detector Loops shall be twisted pair with shield jacket. Shield shall be connected to earth ground only at control panel.

E. Detector wiring shall not be in same conduit with 120/240 VAC wiring or other high current circuits.

F. T-taps or branch circuit connections allowed for class B intelligent loop circuits.

G. Leave 8" wire tails at each device box and 36" wire tails at Control Panel and Remote Annunciator Panel(s)

H. Wiring of initiating device circuits, alarm horn circuits, and alarm strobe circuits shall be #14 AWG minimum.

I. 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).

J. Splices or connections shall be made within approved junction boxes and with approved fittings.

K. Boxes shall be red and labeled "FIRE ALARM SYSTEM" by decal or other approved markings.

L. Horn and strobe circuits shall have separate conductors, and shall operate independently of each other.

M. Tray cable is not acceptable for use as fire alarm systems raceway.

3.4 DEVICE MOUNTING

A. Recommended mounting heights, and requirements are as follows:

1. Audio-Visual Devices

   a. Install flush, semi-flush surface mount allowed only in back of house spaces. (i.e. storage rooms, mechanical rooms, shell space) 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.

2. Manual Stations

   a. Operable part of manual stations shall be installed not less than 3-1/2 ft (42") and not more than 4-1/2 ft (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.

3. 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 ft 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.

D. Contractor shall provide temporary heat detectors to serve areas affected by sprinkler demolition.

1. Provide fire alarm system programming required to connect temporary heat detectors to existing building fire alarm system.
2. Contractor shall disconnect and remove temporary heat detectors upon installation of new sprinkler system. Contractor shall reprogram fire alarm system as required to remove temporary heat detectors from fire alarm system upon completion of new sprinkler work.

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.

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 years 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.

E. Programming of existing fire alarm system to incorporate installation of new devices shall be performed by a technician certified by Honeywell Notifier in order to maintain the UL listing of the overall building fire alarm system, and to extend the UL listing to incorporate the new installation.

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, including Honeywell Notifier representative, in presence of the 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. Contractor shall warrant completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of 2 years from the date of substantial completion of Project.

B. Contractor shall 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 hours. Emergency response shall be provided within 2 hours 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 hrs of notification to Contractor.

G. Repairs and/or replacement shall be completed within 72 hrs 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 hrs system operation training for Owner, Architect/Engineer, and fire department personnel.

B. Training session shall be at 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 refer to Division 01, General Requirements, item “SPECIAL SITE CONDITIONS".

B. Contractor shall notify Owner's security officer 24 hrs in advance of any zones inoperative for period of time exceeding 2 hrs.

C. 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 daily basis in writing, hand delivered.

3.13 DUCT SMOKE DETECTORS

A. Electrical Contractor shall provide and install all duct smoke detectors required for this facility. Refer to Mechanical Drawings for locations of all smoke dampers requiring duct detector installation as well as location of all supply and return ductwork for air handling units requiring duct smoke detectors.

1. Duct smoke detectors shall be provide in each main return and exhaust air plenum of each air handling unit having a capacity greater than 2000 cubic feet per minute (cfm). Such detectors shall be located in a serviceable area downstream of the last duct inlet.
2. Duct smoke detectors shall be provided downstream of the air filters and ahead of any branch connections in air supply systems having a capacity greater than 2000 cub feet per minute (cfm).
3. Duct smoke detectors shall be provided at each connection to a vertical duct or riser servicing two or more stories from a return air duct or plenum of an air handling unit.
4. In return air systems, a smoke duct detector shall be provided where the air leaves each smoke compartment, or in the duct system before the air enters the return air system common to more than one smoke compartment.
   a. Detectors shall be installed at the opening where the return air enters the common return air system. The detectors should be installed up to 12” in front of or bhind the opening and spaced according to the following opening dimensions.
      1) Up to 36” – One detector center in opening.
      2) Up to 72” – Two detectors located at the one-quarter points of the opening.
      3) Over 72” – One additional detector each full 24” of opening.
   b. The number and spacing of detectors in the depth of the opening should be the same as those given for the width.

END OF SECTION

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