

PROJECT MANUAL FOR

# New CTE Building for Bertie High School

**Bertie County Schools**  
*Windsor, North Carolina*

**Hite associates**  
**ARCHITECTURE / PLANNING / TECHNOLOGY**

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**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SCOPE OF WORK:**

The scope of work consists of the furnishing and installing of complete plumbing (exterior and interior) and HVAC systems including miscellaneous systems. The Mechanical Contractor (hereafter referred to as "the Contractor", either Plumbing or HVAC) shall provide all supervision, labor, materials, equipment, machinery, and any and all other items necessary to complete the systems. The Contractor shall note that all items of equipment are specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on the drawings and as required for complete systems.

It is the intention of the Specifications and Drawings to call for finished work, tested and ready for operation.

Any apparatus, appliance, material, or work not shown on the drawings but mentioned in the specifications, or vice versa, or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered, and installed by the Contractor without additional expenses to the Owner. Minor details not usually shown or specified, but necessary for proper installation and operation, shall be included in the Contractor's estimate, the same as if herein specified or shown.

With submission of bid, the Contractor shall give written notice to the Architect of any materials or apparatus believed inadequate or unsuitable, in violation of laws, ordinances, rules, and any necessary items or work omitted. In the absence of such written notice, it is mutually agreed that the Contractor has included the cost of all required items in his proposal, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensation.

NOTICE TO BIDDERS, INSTRUCTIONS TO BIDDERS, SUPPLEMENTARY INSTRUCTIONS, GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, SPECIAL CONDITIONS, GENERAL REQUIREMENTS bound in the front of this document are included as a part of the specifications for this work.

**MECHANICAL DRAWINGS AND SPECIFICATIONS:**

The mechanical drawings are diagrammatic and indicate the general arrangement of fixtures, equipment, and work included in the contract. Consult the architectural, structural and electrical drawings and details for exact location and dimensions of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.

The Contractor shall follow drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Architect shall be notified before proceeding with installation. If directed by the Architect, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.

The plans and these specifications are intended to describe, imply and convey the materials and equipment as well as necessary labor, required for the installation as outlined in the paragraph entitled "Scope of Work". Any omissions from either the drawings or these specifications are unintentional, and it shall be the responsibility of this Contractor to call to the attention of the Architect or Engineer any pertinent omissions before submission of a bid. The drawings which accompany these specifications are not intended to show in complete detail every fitting which may be required; however wherever reasonable implied by the nature of

the work, any such material or equipment shall be installed by this Contractor as a part of his contract price. In no case will any extra charge be allowed unless authorized in writing by the Architect or Engineer.

The Contractor shall arrange with the General Contractor for required concrete and masonry chases, openings, and sub-bases so as not to delay progress of work. Work shall be installed sufficiently in advance of other construction to conceal piping and to permit work to be built in where required.

It shall be understood and agreed by all parties that where the words "Furnish", "Install", and / or "Provide" appear, the following definitions apply:

- Furnish - to supply or give
- Install - to place, establish or fix in position
- Provide - to furnish and install as defined above

**CODES, PERMITS, AND FEES:**

The Contractor shall give all necessary notices, including electric and telephone utilities, obtain all permits, and pay all government taxes, fees, and other costs, including utility connections or extensions in connection with his work file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates of inspection for his work and deliver same to the Architect before request for acceptance and final payment for the work.

The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, drawings (in addition to contract drawing and documents) in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not shown on drawings and / or specified.

Work and materials shall conform to the latest rules of the National Board of Fire Underwriter's Code and Regulations of the State Fire Marshall, and, or guarding of any moving parts, or otherwise hazardous conditions. Nothing in these specifications shall be construed to permit work not conforming to the most stringent of applicable codes.

The State Plumbing and Mechanical codes, and the mechanical requirements as established by the State and Local Fire Marshall, and rules and regulations of the local utilities serving the project are hereby made part of this specification. Should any changes be necessary in the drawings or specifications to make the work comply with these requirements, the Contractor shall notify the Architect.

**VERIFICATION OF DIMENSIONS, DETAILS, EXISTING FIELD CONDITIONS:**

The Contractor shall visit the premises prior to bidding, and thoroughly familiarize himself with all details of the work, working conditions, verify dimensions in the field, provide advice of any discrepancy, and submit shop drawings of any changes he proposes to make in quadruplicate for approval before starting any work. The Contractor shall install all equipment in a manner to avoid building interference. No Change Order for extra work will be considered for items that were evident during a site visit.

The locations of existing underground utilities are shown in an approximate way only and have not been independently verified by the Owner or its representative. The Contractor shall determine the exact location of all existing utilities before commencing work and agrees to be fully responsible for any and all damages which might be occasioned by the Contractor's failure to exactly locate and preserve any and all underground utilities.

**ACCEPTABLE MANUFACTURERS:**

Acceptable manufacturers, as specified in the Contract Documents, implies that the specified manufacturer may produce acceptable products equal in quality of materials and performance to such item specified. The

Contractor will be required to provide products meeting or exceeding the "Standard of Quality and Performance" as dictated by the product selection noted.

**SHOP DRAWINGS AND EQUIPMENT SUBMITTALS:**

The Contractor shall submit minimum of five (5) and maximum of seven (7) copies of the shop drawings to the Architect for approval within thirty (30) days after the award of the general contract. If such a schedule cannot be met, the Contractor may request in writing for an extension of time to the Architect. If the Contractor does not submit shop drawings in the prescribed time, the Architect has the right to select the equipment.

Shop drawings shall be submitted on all major pieces of mechanical equipment. Each item of equipment proposed shall be a standard catalog product of an established manufacturer. Certain major groups of equipment shall be provided from a singular manufacturer. The shop drawing shall give complete information on the proposed equipment. Each item of the shop drawings shall be properly labeled, indicating the intended service of the material, the job name, and the MC's name.

The shop drawings shall be neatly bound in five (5) sets and submitted to the Architect with a letter of transmittal. The letter of transmittal shall list each item submitted along with the manufacturer's name.

Approval rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are approved, said approval does not mean that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the contract drawings and specifications.

**AS-BUILT DRAWINGS:**

The Contractor shall maintain accurate records of all deviations in work as actually installed from work indicated on the drawings. On completion of the project, two (2) complete sets of marked-up prints shall be delivered to the Architect.

**MAINTENANCE AND OPERATING MANUALS:**

Upon completion, the MC shall turn over to the Architect three (3) sets of complete maintenance manuals and parts list for all mechanical equipment used on the job. Manuals shall include equipment data, manufacturer's recommended maintenance, parts list, assembly drawings, warranties, and name, address, and phone numbers of suppliers of equipment. Indicate project name on cover and binder side.

**COORDINATION WITH OTHER TRADES:**

Coordinate all work required under this section with work of other sections of the specifications to avoid interference. Bidders are cautioned to check their equipment against space available as indicated on drawings and shall make sure that proposed equipment can be accommodated. If interferences occur, Contractor shall bring them to attention in writing, prior to signing of contract; or, Contractor shall at his own expense provide proper materials, equipment, and labor to correct any damage due to defects in his work caused by such interference.

**INSPECTION AND CERTIFICATES:**

On the completion of the entire installation, the approval of the Architect and Owner shall be secured, covering the installation throughout. The Contractor shall obtain and pay for Certificate of Approval from the public authorities having jurisdiction. A final inspection certificate shall be submitted to the Architect prior to final payment. Any and all costs incurred for fees shall be paid by the Contractor.



**EQUIVALENTS:**

When material or equipment is mentioned by name, it shall form the basis of the Contract. When approved by the Architect in writing, other material and equipment may be used in place of those specified, but written application for such substitutions shall be made to the Architect as described in the Bidding Documents. The difference in cost of substitute material or equipment shall be given when making such request. Approval of substitute is, of course, contingent on same meeting specified requirements and being of such design and dimensions as to comply with space requirements.

**WORKMANSHIP AND MATERIALS:**

All workmanship shall be of the best quality, and all equipment and materials incorporated in the work under this Contract shall be new and equal to or better than the grade specified. Deviations in workmanship or materials will be corrected by the Contractor at his expense.

**WARRANTY:**

The Contractor shall submit upon completion of the work, a warranty by his acceptance of the contract, that all work installed will be free from defects in workmanship and materials. If, during the period of one year, or as otherwise specified from date of Certificate of Completion and acceptance of work, any such defects in workmanship, materials, or performance appear, the Contractor shall, without cost to the Owner, remedy such defects within reasonable time to be specified in notice from the Architect. In default, the Owner may have such work done and charge cost to Contractor.

**CUTTING AND PATCHING:**

The Mechanical Contractor (both Plumbing and HVAC) shall furnish sketches to the General Contractor showing the locations and sizes of all openings and chases, and furnish and locate all sleeves and inserts required for the installation of the mechanical work before the walls, floors, and roof are built. The Mechanical Contractor shall reimburse the General Contractor for the cost of cutting and patching, and shall be responsible for the cost of cutting and / or patching where any mechanical items were not installed or where incorrectly sized or located. The Contractor shall do all drilling required for the installation of his hangers. See also Section 01050, Cutting and Patching.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Basic methods and requirements for Division 15, MECHANICAL, applies to all sections of Division 15.
- B. Definitions:
  - 1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
  - 2. Option or optional: Contractor's choice of an alternate material or method.

**1.2 RELATED WORK**

- H. Section 15250, INSULATION.
- K. Section 15980, TESTING, ADJUSTING, AND BALANCING.
- L. Section 16400, SERVICE AND DISTRIBUTION.

**1.3 QUALITY ASSURANCE**

- A. Section 15980, TESTING, ADJUSTING, AND BALANCING.
- B. Equipment Vibration Tolerance:
  - 1. The allowable vibration tolerance shall be in accordance with 1999 ASHRAE Applications Handbook, Table 1, 46.3. Equipment specifications require factory balancing of equipment to this tolerance.
  - 2. After air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.
- C. Products Criteria:
  - 1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. See other specification sections for any exceptions.
  - 2. Equipment Service: Products shall be supported by a service organization which maintains a complete inventory of repair parts and is located reasonably close to the site.
  - 3. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
  - 4. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
  - 5. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
  - 6. Asbestos products or equipment or materials containing asbestos shall not be used.
- D. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Resident Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

E. Warranty: Section 01001, GENERAL CONDITIONS.

#### 1.4 SUBMITTALS

- A. Submit in accordance with General Provisions.
- B. Manufacturer's Literature and Data: Submit under the pertinent section rather than under this section.
  - 1. Submit belt drive with the driven equipment.
  - 2. Submit electric motor data and variable speed drive data with the driven equipment.
  - 3. Equipment and materials identification.
  - 4. Fire-stopping materials.
  - 5. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
  - 6. Wall, floor, and ceiling plates.
- C. Coordination Drawings; provide where required in accordance with Section 01001, GENERAL CONDITIONS, Article, SUBCONTRACTS AND WORK COORDINATION. Provide:
  - 1. Mechanical equipment rooms.
  - 2. Interstitial space.
  - 3. Hangers, inserts, supports, and bracing.
  - 4. Pipe sleeves.
  - 5. Duct or equipment penetrations of floors, walls, ceilings, or roofs.
- D. Maintenance Data and Operating Instructions:
  - 1. Maintenance and operating manuals in accordance with Section 01010, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
  - 2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.
- E. Provide copies of approved HVAC equipment submittals to the Testing, Adjusting and Balancing Subcontractor.

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Federal Specifications (Fed. Spec.):
  - FF-S-325 ..... Shield, Expansion; Nail, Expansion; and Nail, Drive Screw  
(Devices, Anchoring, Masonry)
- C. Air Conditioning and Refrigeration Institute (ARI):
  - 430-89 ..... Central Station Air-Handling Units
- D. American National Standard Institute (ANSI):
  - B31.1-98 ..... Power Piping
- E. Rubber Manufacturers Association (ANSI/RMA):
  - IP-20-88 ..... Drives Using Classical V-Belts and Sheaves - Cross Sections A,  
B, C, D, and E
  - IP-21-91 ..... Drives Using Double-V (Hexagonal) Belts (AA, BB, XX, DD Cross  
Sections)
  - IP-22-91 ..... Drives Using Narrow Multiple V-Belts (3V, 5V, and 8V Cross  
Sections)
- F. Air Movement and Control Association (AMCA):
  - 410-96 ..... Recommended Safety Practices for Air Moving Devices
- G. American Society of Mechanical Engineers (ASME):
  - Boiler and Pressure Vessel Code (BPVC):

- SEC IX-98 ..... Qualifications Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
- H. American Society for Testing and Materials (ASTM):
  - A36/A36M-97 ..... Carbon Structural Steel
  - A575-96 ..... Steel Bars, Carbon, Merchant Quality, M-Grades
  - E84-98 ..... Surface Burning Characteristics of Building Materials
  - E119-98 ..... Fire Tests of Building Construction and Materials
- I. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:
  - SP-58-93 ..... Pipe Hangers and Supports-Materials, Design and Manufacture
  - SP-69-96 ..... Pipe Hangers and Supports-Selection and Application
- J. National Association of Plumbing - Heating - Cooling Contractors (NAPHCC):
  - 1996 ..... National Standard Plumbing Code
- K. National Fire Protection Association (NFPA):
  - 90A-96 ..... Installation of Air Conditioning and Ventilating Systems
  - 101-97 ..... Life Safety Code

**PART 2 - PRODUCTS**

**2.1 BELT DRIVES**

- A. Type: ANSI/RMA standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.
- B. Dimensions, rating and selection standards: ANSI/RMA IP-20 and IP-21.
- C. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.
- D. Maximum Speed: 5000 feet per minute.
- E. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take-up.
- F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.
- F. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.
- H. Sheaves and Pulleys:
  - 1. Material: Pressed steel, or close grained cast iron.
  - 2. Bore: Fixed or bushing type for securing to shaft with keys.
  - 3. Balanced: Statically and dynamically.
  - 4. Groove spacing for driving and driven pulleys shall be the same.
- I. Drive Types, Based on ARI 435:
  - 1. Provide adjustable-pitch or fixed-pitch drive as follows:
    - a. Fan speeds up to 1800 RPM: 7.5 horsepower (10 kW) and smaller.
    - b. Fan speeds over 1800 RPM: 2.2 horsepower (3 kW) and smaller.
  - 2. Provide fixed-pitch drives for drives larger than those listed above.
  - 3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

**2.2 DRIVE GUARDS**

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive

guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

- B. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- C. Access for Speed Measurement: 1" diameter hole at each shaft center.

### **2.3 ELECTRIC MOTORS**

- A. Section 15170, MOTORS, specifies the applicable requirements for electric motors. Provide special energy efficient motors as scheduled. Unless otherwise specified for a particular application use electric motors with the following requirements.
- B. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC).
- C. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type. Each two-speed motor shall have two separate windings. Provide a time-delay (20 seconds minimum) relay for switching from high to low speed.
- D. Rating: Continuous duty at 100 percent capacity in an ambient temperature of 104 degrees F; minimum horsepower as shown on drawings; maximum horsepower in normal operation not to exceed nameplate rating without service factor.
- E. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

### **2.4 VARIABLE SPEED MOTOR CONTROLLERS**

- A. Removed

### **2.5 EQUIPMENT AND MATERIALS IDENTIFICATION**

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals.
- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 3/16" high of brass with black-filled letters, or rigid black plastic with white letters permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.
- C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 3/16" high riveted or bolted to the equipment.
- D. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

### **2.6 FIRESTOPPING**

See Sheet FP – 001. FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer also to Section 15250, INSULATION, for firestop pipe and duct insulation.

### **2.7 GALVANIZED REPAIR COMPOUND**

Mil. Spec. DOD-P-21035B, paint form.

### **2.8 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS**

- A. Vibration Isolators: see drawing details.

- B. Supports For Roof Mounted Items:
  - 1. Equipment: Equipment rails shall be galvanized steel, 8 gauge, with integral baseplate, continuous welded corner seams, factory installed 2 by 4 treated wood nailer, 18 gauge galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 11 inches. For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
  - 2. Pipe/duct pedestals: Provide a galvanized unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.
  
- D. For Attachment to Concrete Construction:
  - 1. Concrete insert: Type 18, MSS SP-58.
  - 2. Self-drilling expansion shields and machine bolt expansion anchors: Fed. Spec. FF-S-325, permitted in concrete not less than four inches thick. Applied load shall not exceed one-fourth the proof test load listed in Fed. Spec. FF-S-325.
  - 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than four inches thick when approved by the Resident Engineer for each job condition. Applied load shall not exceed one-fourth the proof test load listed in Fed. Spec. FF-S-325.
  
- F. For Attachment to Steel Construction: MSS SP-58.
  - 1. Welded attachment: Type 22.
  - 2. Beam clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 7/8-inch outside diameter.
  
- F. Attachment to Metal Pan or Deck: As required for materials specified in Division 5.
  
- G. For Attachment to Wood Construction: Wood screws or lag bolts.
  
- H. Hanger Rods: See Section 15060.
  
- J. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 1-5/8 inches by 1-5/8 inches, No. 12 gauge, designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
  - 1. Allowable hanger load: Manufacturers rating less 91kg ( 200 pounds).
  - 2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2-inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.
  
- K. Pipe Hangers and Supports:
  - 1. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.
  - 2. Plumbing Piping (Other Than General Types):
    - a. Horizontal piping: Type 1, 5, 7, 9, and 10.
    - b. Chrome plated piping: Chrome plated supports.
    - c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.
    - d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 1.3 mm (18 gage) minimum.
  
- L. Pre-insulated Calcium Silicate Shields:
  - 1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
  - 2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
  - 3. Shield thickness shall match the pipe insulation.
  - 4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.

- a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 1 inch past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
  - b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.
5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.
- M. Seismic Restraint of Piping:
1. Design criteria is as follows:
    - a. Piping resiliently supported: 120 percent of the weight of the systems and components and contents.
    - b. Piping not resiliently supported: 60 percent of the weight of the system components and contents.
    - c. Except as noted above, meet the more severe requirements of the Local Code and the latest Uniform Building Code for determining seismic force  $F_p$ .
  2. Provide one of the following options:
    - a. Design and installation to meet the criteria listed above, and meet requirements of the latest Sheet Metal and Air Conditioning Contractors National Association (SMACNA), Seismic Restraint Manual Guidelines for Mechanical Systems for the prescribed Seismic Hazard Level
    - b. Design and installation to meet the criteria listed above, and meet the most current requirements of the National Uniform Seismic Installation Guidelines (NUSIG). Contractor shall submit all design tables and information for the design force levels, stamped and signed by a professional engineer registered in the State where project is located.
    - c. Where SMACNA or NUSIG requirements are not met completely, submit proposed alternate details and calculations to completely address seismic bracing requirements. Such designs shall use more severe of the Local Code and the Uniform Building Code requirements for determining seismic forces, and be performed, stamped and signed by a professional engineer registered in the State where project is located. Revise if necessary any details shown on the contract drawings for vertical support and lateral bracing, and submit for the approval of the Owner to meet the design criteria listed above.

## **2.9 PIPE PENETRATIONS**

- A. Install sleeves during construction for other than blocked out floor openings for risers in chases.
- B. To prevent accidental liquid spills from passing to a lower level, provide the following:
  1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.
  2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
  3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from this requirements must receive prior approval of Resident Engineer.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms and similar. Except in mechanical rooms, connect sleeve with floor plate.
- G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.
- H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

- I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.
- J. Sealant and Adhesives: Shall be as specified in Section 07920, SEALANTS AND CAULKING.

## **2.10 TOOLS AND LUBRICANTS**

- A. Furnish, and turn over to the Owner special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the Owner.
- D. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

## **2.11 WALL, FLOOR AND CEILING PLATES**

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- B. Protection and Cleaning:
  - 1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the Owner. Damaged or defective items in the opinion of the Owner, shall be replaced.
  - 2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- C. Concrete and Grout: Use concrete and shrink compensating grout 25 MPa (3000 psi) minimum, specified in Section 03300, CAST-IN-PLACE CONCRETE.
- D. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- E. Install steam piping expansion joints as per manufacturer's recommendations.
- F. Work in Existing Building:
  - 1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01010, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).



2. As specified in Section 01010, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.
  3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Owner. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the Owner for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After Owner's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.
- G. Exterior: Seal all pipe and duct penetrations with silicone sealant to prevent entrance of insects.
- H. Switchgear Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints.
- I. Inaccessible Equipment:
1. Where the Engineer / Owner determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Owner.
  2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

### **3.2 PIPE AND EQUIPMENT SUPPORTS**

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the Owner.
- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.
- C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
  2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Plumbing horizontal and vertical pipe supports, refer to the State Plumbing Code.

### **3.3 MOTOR AND DRIVE ALIGNMENT**

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

### **3.4 LUBRICATION**

Field check and lubricate equipment requiring lubrication prior to initial operation.

### **3.5 STARTUP AND TEMPORARY OPERATION**

Start up equipment as described in equipment specifications. Verify that vibration is within specified tolerance prior to extended operation. Temporary use of equipment is specified in Section 01010, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

### **3.6 OPERATING AND PERFORMANCE TESTS**

- A. Prior to the final inspection, perform required tests as specified in Section 01010, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the Owner.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Owner.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I: GENERAL**

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Submittals: Provide Product Data for each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

**PART II: PRODUCTS**

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory fabricated components.
  - 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
  - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.
  - 1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
  - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- C. Thermal-Hanger Shield Inserts: 100-psi (690-kPa) minimum compressive strength insulation, encased in sheet metal shield.
  - 1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellant-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
  - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
  - 3. For Clevis or Band Hanger Insert and shield cover lower 180 degrees of pipe.
  - 4. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.
- D. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- E. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- F. Grout ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.
  - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
  - 2. Properties: Non-staining, non-corrosive, and non-gaseous.

**PART III: EXECUTION**

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.

- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.
- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN15 to DN750).
  2. -Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
  3. Adjustable Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
  4. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30 (DN15 to DN750).
- D. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Tumbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- E. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
  2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  5. C-Clamps (MSS Type 23): For structural shapes.
  6. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    - a. Light (MSS Type 31): 750 lb. (340 kg).
    - b. Medium (MSS Type 32): 1500 lb. (675 kg).
    - c. Heavy (MSS Type 33): 3000 lb. (1350 kg).
  7. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  8. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- F. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
- G. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

1. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- L. Insulated Piping: Comply with the following:
  1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits according to ASME B31.9.
  2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
  3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
  4. Shield Dimensions for Pipe: Not less than the following:
    - a. NPS 1/4 to NPS 3-1/2 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
  5. Insert Material: Length at least as long as protective shield.
  6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- M. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations. Comply with AWS DI.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
  1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  2. Obtain fusion without undercut or overlap.
  3. Remove welding flux immediately.
  4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.
- N. Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- O. Touching Up: 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. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- P. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- Q. Install all hangers and supports prior to application of fire-proofing by GC. Any fire-proofing damaged by this Contractor shall be repaired by this Contractor.

*END OF SECTION*

**AIR COMPRESSOR:**

New rotary screw air compressor with integral air receiver tank and air dryer. Air Compressor shall have a variable speed, direct drive motor. See plans for size of tank(s) and compressor motor horsepower (HP).

Quincy, Ingersoll Rand, Chicago Pneumatic, Champion, Kaeser, and Sullivan-Palatek shall be acceptable manufacturers. Other manufacturers shall be submitted for approval by Engineer prior to bid.

**COMPRESSED AIR PIPING:**

Compressed air piping shall be rigid, copper or aluminum alloy.

Copper pipe above finish grade or floor, shall be seamless hard drawn annealed type K copper tubing, ASTM B-88, with wrought copper ASA B-16.22 fittings, and lead free soldered joints. Compressed air piping shall be air tested at 200 psig for a minimum of 4 hours or 120 psig for 24 hours and shall be witnessed by Engineer and/or Building Inspector.

Aluminum alloy piping shall be grade 6063 from 3/4" – 2" diameter, and grade 5052 from 3" – 6" diameter. Aluminum piping shall meet or exceed ASTM B241, ASME B31.1, and ASME B31.9. Aluminum piping shall be rated for a minimum of 190 psig operating pressure. Fittings shall be manufacturer's approved fittings and shall be installed in accordance with manufacturer's recommendations. Aluminum piping shall be pressure tested at 190 psig for a minimum of 4 hours or 120 psig for 24 hours and shall be witnessed by Engineer and/or Building Inspector.

Clean, prime, and paint all exposed copper and aluminum compressed air piping Blue as indicated by the OSHA pipe color paint system. Aluminum piping manufactured with a blue powder coating is acceptable. All compressed air piping shall bear blue labels with white lettering. Labels shall read "COMPRESSED AIR".

**COMPRESSED AIR VALVES:**

Compressed air valves shall be tested and certified for this application and meet current ANSI standards for compressed air systems. Ball valves shall be used in piping up through 2". Acceptable ball valve manufacturers are Apollo, Watts, Nibco, and Grinnell. Ball valves shall have brass or bronze body and ball, lever handle, teflon seats and seal, and rated up to 200 psig at 250°F.

**RETRACTABLE HOSE REELS:**

Hose reels shall have powder coated steel frames with (2) position hose guide, premium duty spring, adjustable "stop block" and premium quality 1/2" rubber hose rated for 250 psi minimum. Hose shall terminate with a 1/4" "female" quick connect fitting. Hose length shall be 50'-0" minimum. Provide Reelcraft Series 5000 or equal by Graco, RapidAir, Speedair, Dewalt or Blu Bird.

**INSTALLATION:**

Installation shall be in accordance with current N. C. State Building Code. Provide shut-off valve, dirt leg, union and quick disconnect at each piece of equipment. Provide pipe hangers at specified intervals per current NCSBC and standards for copper tubing or aluminum tubing.

All compressed air drops from compressed air loop piping shall be installed using a tee fitting. Pipe saddle fittings shall not be acceptable.

Contractor shall consult manufacturer's recommendations for expansion joints and install where required.

CONNECTIONS TO EQUIPMENT:

Provide flexible, stainless steel, braided hose for connection of air compressor to compressed air piping. Flexible hose shall be 18" minimum in length. Refer to plans and air compressor equipment for exact hose diameter. Provide all fittings, adapters, and/or reducers as required for connection.

Provide compressed air piping and final connections at all locations indicated on the plans. Provide rough-ins with shut-off valve and 1/4" female quick disconnect.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I: GENERAL**

A. Submittals: Submit Product Data for each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

**PART II: PRODUCTS**

A. Pressure and Temperature Ratings: As required to suit system pressures and temperatures.

B. Sizes: Same size as upstream pipe, unless otherwise indicated.

C. Operators: Use specified operators and handwheels, except provide the following special operator features:

1. Handwheels: For valves other than quarter turn.
2. Lever Handles: For quarter-turn valves 6 inches (DN 1 50) and smaller, except for plug valves, which shall have square heads. Furnish Owner with 1 wrench for every 1 0 plug valves.

D. Threads: ASME B1.20.1.

E. Flanges: ASME B16.1 for cast iron, ASME B16.5 for steel, and ASME B16.24 for bronze valves.

F. Solder Joint: ASME B16.18. Where soldered end connections are used, use solder having a melting point below 840 deg F (450 deg C) for gate, globe, and check valves; below 421 deg F (216 deg C) for ball valves.

G. Gate Valves, 2-1/2 Inches (DN65) and Smaller: MSS SP-80; Class 125, 200-psi (1380-kPa) cold working pressure (CWP), or Class 150, 300-psi (2070-kPa) CWP; ASTM B 62 cast-bronze body and bonnet, solid-bronze wedge, copper-silicon alloy rising stem, teflon-impregnated packing with bronze packing nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

H. Ball Valves, 4 Inches (DN 1 00) and Smaller: MSS SP-1 1 0, Class 150, 600-psi (4140-kPa) CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch (DN15) valves and smaller and conventional port for 3/4-inch (DN20) valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:

1. Operator: Vinyl-covered steel lever handle with hole for valve tag chains.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: For operator handles.

I. Globe Valves, 2-1/2 Inches (DN65) and Smaller: MSS SP-80; Class **125**, 200-psi (1 380-kPa) CWP, or Class 150, 300-psi (2070-kPa) CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or teflon disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

J. Globe Valves, 3 Inches (DN80) and Larger: MSS SP-85, Class 125, 200psi (1 380-kPa) CWP, ASTM A 126 cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with cast-iron follower, flanged end connections; and with cast-iron handwheel.



**PART III: EXECUTION**

- A. Install valves as indicated, according to manufacturers written instructions.
- B. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.
- D. Locate valves for easy access and provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the center of the pipe.
- F. Install valves in a position to allow full stem movement.
- G. Installation of Check Valves: Install for proper direction of flow. Install in a horizontal position with hinge pin level.
- H. Select valves with the following ends or types of pipe/tube connections:
  - 1. Copper Tube Size, 2-1/2 Inches (DN65) and Smaller Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
- I. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.
- J. Domestic Water Systems Applications: Use the following valve types:
  - 1. Gate Valves: Class 125, bronze or cast-iron body to suit piping system.
  - 2. Ball Valves: Class 150, 600-psi (4140-kPa) CWP, with stem extension.
  - 3. Plug Valves: Neoprene-faced plug, Buna N packing.
  - 4. Globe Valves: Class 125, bronze or cast-iron body to suit piping system, and bronze or teflon disc.
  - 5. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or elastomer-coated ductile iron disc; EPDM or Buna N sleeve and stem seals.

*END OF SECTION*

RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

EXCAVATING AND BACKFILLING FOR MECHANICAL WORK:

Refer to specification sections 02210 - *Trenching and Backfilling for Utilities* and 02220 - *Earthwork*

In general, DO NOT excavate for mechanical work until work is ready to proceed without delay to maintain minimum time lapse from excavation to completion of backfilling. Excavate with vertical sided excavations to greatest extent possible providing sheeting and cross-bracing to sustain sides where necessary. All shoring and sheeting required to protect the excavation shall be constructed and maintained in strict accordance with all applicable State and Federal Regulations.

Excavate trench for piping to uniform width with 18" minimum clearance both sides of piping providing adequate working room. Correct over-excavation by means of backfilling with concrete, or tamped and compacted backfill material approved for other backfilling work. All excavated materials not suitable or required for backfill shall be removed as directed or required in a lawful manner.

Whenever wet or otherwise unstable soil that is incapable of adequately supporting pipe is encountered in trench bottoms, remove such material to depth required and replace to the proper grade with selected material compacted as hereinafter specified for backfilling of pipe. Provide unit prices on Form of Proposal.

Support pipe directly on undisturbed soil. Do not excavate beyond required or indicated depth, and hand-excavate bottom cut to accurate elevations. Do not backfill until installed mechanical work has been tested and accepted. Provide 6" wide utility warning tape with magnetic detection 6 to 8" below finish grade during backfill operation over all piping exterior to building.

Conditions backfill material by either drying or adding water uniformly, necessary to facilitate compaction to required densities. Do not backfill with frozen soil materials. Backfill simultaneously on opposite sides of mechanical work and compact simultaneously without dislocating work from installed positions. Continue backfilling in 8" layers, uniformly compacted to 85% density for cohesive soils, 90% for cohesionless soils (90% for cohesive, 95% for cohesionless soils under paved surfaces) using power-driven hand-operated compaction equipment. Correct improperly backfill that has settled.

All paving and concrete removed or cut, shall be replaced or patched to satisfaction of Architect.

All landscaping (trees, shrubbery, grass, etc.) removed or damaged, shall be replaced to satisfaction of Architect.

Existing utility lines (gas, electric, communications, sewer, water, etc.) shall be protected from damage during excavation and backfilling, and, if damaged, shall be repaired by the Contractor at his expense. In the event that the Contractor damages any existing utility lines, he shall report thereof immediately. If it is determined that repairs shall be made by the Contractor, such repairs shall be ordered under terms of other sections of these specifications.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I - GENERAL**

**SCOPE:**

This Section includes basic requirements for motors. It includes motors that are factory-installed as part of equipment and appliances as well as field-installed motors.

**QUALITY ASSURANCE:**

1. Comply with NFPA 70, "National Electrical Code.
2. Comply with NEMA MG-1, "Motors and Generators".
3. Comply with UL 1004, "Motors, Electric".
4. Comply with NCSBC, Volume X, Chapter 4, Section 401.2, "Electric Motors".

**PART II - PRODUCTS**

**A. MOTORS, GENERAL**

1. General: Requirements below apply to motors covered by this Section except as otherwise indicated.
2. Motors 1 hp and larger: Polyphase.
3. Motors Smaller Than  $\frac{3}{4}$ " hp and less: Single-phase.
4. Frequency Rating: 60 Hz.
5. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
  - a. 120V Circuit: 115V - motor rating.
  - b. 208V Circuit: 200V - motor rating.
  - c. 480V Circuit: 460V - motor rating.
6. Service factors indicated for motors are minimum values and apply at frequency and utilization voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10 percent of motor voltage rating.
7. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.
8. Temperature Rise: Based on 40 deg C ambient except as otherwise indicated.
9. Enclosure: Open dripproof.
10. Minimum full-load efficiency per tables 401.2.1 a & b of NCSBC Volume X Energy Code.

**B. POLYPHASE MOTORS**

1. General: Squirrel-cage induction-type conforming to the following requirements except as otherwise indicated.

2. NEMA Design Letter Designation: "b".
3. Internal Thermal Overload protection For Motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.
4. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading of the application.
5. Rugged Duty Motors: Totally enclosed with 1.25 minimum service factor. Provide motors with regreasable bearings and equipped with capped relief vents. Insulate windings with nonhygroscopic material. External finish shall be chemical resistant paint over corrosion resistant primer. Provide integral condensate drains.

**C. SINGLE-PHASE MOTORS**

1. General: Conform to the following requirements except as otherwise indicated.
2. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application.
  - a. Permanent Split Capacitor.
  - b. Split-Phase Start, Capacitor-Run.
  - c. Capacitor-Start, Capacitor-Run.
3. Shaded-Pole Motors: Use only for motors smaller than 1/20 hp.
4. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens the power supply circuit to the motor, or a control circuit arranged for external connection. Protection operates when winding temperature exceeds a safe value calibrated to the temperature returns to normal range except as otherwise indicated.
5. Bearings, belt connected motors and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, prelubricated sleeve bearings may be used for other single phase motors.

**PART III - EXECUTION**

**INSTALLATION:**

Install motors in accordance with manufacturer's published instruction.

**PART IV - COMMISSIONING**

1. Check operating motors, both factory and field-installed, for unusual conditions during normal operation. Coordinate with the commissioning of the equipment for which the motor is a part.
2. Report unusual conditions.
3. Correct deficiencies of field-installed units.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART 1 - GENERAL**

**DESCRIPTION OF WORK:**

This section contains the requirements relating to the materials and methods used to identify items described in Division 15.

**PART 2 - PRODUCTS**

**ENGRAVED PLASTIC-LAMINATE SIGNS:**

Provide engraving stock melamine plastic laminate, in the sizes and thickness indicated, engraved with engraver's standard letter style of the sizes and wording indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Plastic laminate thickness shall be 1/16" for units up to 20 square inches or 8" length; 1/8" for larger units. Provide self-tapping stainless steel screws.

**PART 3 - EXECUTION**

**INSTALLATION REQUIREMENTS:**

**A. COORDINATION:**

Coordinate new labeling with existing labeling through Project Manager. Where identification is to be applied to surfaces that require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, identification shall be installed after completion of covering and painting. Identification is to be installed prior to installation of acoustical ceilings and similar removable concealment.

**B. DUCTWORK IDENTIFICATION:**

1. General: Provide for identification of air supply, return, exhaust, intake, and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black and white.
2. Locations: Ductwork shall be identified every 20' in spaces with removable ceilings and at each access door in spaces with hard ceilings. Exposed ductwork shall be identified every 20' in mechanical rooms. As described above, ductwork shall be labeled on both sides of floor and wall penetrations.

**C. MECHANICAL EQUIPMENT IDENTIFICATION:**

Provide for engraved plastic laminate sign on or near each major item of mechanical equipment and each operational device. Provide signs for the following general categories of equipment and operational devices:

1. Main control and operating valves, including safety devices.
2. Air conditioning indoor and outdoor units.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**GENERAL:**

Furnish and install complete building potable water supply system from connection provided by Sitework Contractor unless indicated otherwise on the drawings. Include utility tap fee allowance specified Section 01056-1 in bid.

**WATER SERVICE PIPING:**

Water service piping 4" and larger from utility main tap to point designated on drawings outside building shall be AWWA Standard C-900 PVC. The pipe joints shall be integral bell type with elastomeric gaskets. The pipe shall be pressure rated for 150 psi with dimension ratio of 18 between wall thickness and bell. Pipe shall be supplied in 20 ft. lengths.

Water service piping 3" and less outside building shall be IPS rated SDR 21 PVC water pipe conforming to material requirements of ASTM D-2241 in accordance with ASTM D-1781.

**BUILDING WATER SUPPLY PIPING AND FITTINGS:**

**BELOW GRADE:**

Building water main buried in earth and/or under concrete slab, where indicated on the plans, shall be seamless type K soft annealed copper tubing, ASTM B-88, with wrought copper ASA B-16.22 fittings and silver type solder brazed joints.

Unless indicated otherwise in the drawings, contractor is responsible for water meter and utility tap fees. Coordinate building ground to copper pipe with Electrical Contractor as required. Refer to Section 15150 for excavating and backfilling.

**ABOVE GRADE:**

Water piping above ground shall be seamless type L hard drawn copper tubing, ASTM B-88, with wrought copper ASA B-16.22 fittings, and 95/5 soldered joints (lead-free solder).

**EXPOSED WATER PIPING:**

All exposed water piping to plumbing fixtures, especially in Kitchen areas, shall be IPS chrome-plated yellow brass pipe with polished chrome-plated 125-pound screwed brass fittings, except piping noted to be run exposed in mechanical or utility areas. Any joints leaking shall be reconstructed with new materials. Flexible pipe or hose is not acceptable for final connection to any fixture on this project.

**PIPING INSTALLATION:**

Water piping in building and above grade shall be accurately cut to measurements established at the site, worked into place without springing or forcing, and shall satisfactorily clear all window, door, and other openings and obstructions. Excessive cutting or other weakening of the structure to facilitate piping installation will not be permitted. Sleeves shall be provided for pipe penetrating floors, walls, and roofs. Access doors and panels shall be provided as specified.

Piping shall generally run level with all changes in direction made with fittings. Branch connections shall be made with fittings. Branch lines may be taken off top of main, bottom of main, or side of main using such

crossover fittings as may be required by structural or installation conditions. All service pipe, valves, and fittings shall be kept a sufficient distance from other work to permit finished covering not less than 1/2" from such other work and not less than 1/2" between finished covering on the different service.

No water piping shall be buried in floors unless specifically indicated on drawings or approved; when buried, pipe shall be corrosion and mechanically protected. Eccentric reducers with top level shall be provided where changes in size are made.

Soldered joints shall be made up with 95-5 (tin-antimony) solder (for piping 1-1/2" and less; joints for tubing larger than 1-1/2" shall be silver brazed with "Sil-fos," "Easyflo" or "Phos-copper"). Surfaces to be joined shall be thoroughly cleaned with steel wool and paste type flux shall be applied evenly to fitting and tube. Tubing shall be inserted to shoulder in fitting and heat applied evenly to fitting until solder starts to flow into socket by capillary action. Excess solder starts to flow into socket by capillary action. Excess solder shall be wiped off before joint cools. All joints between dissimilar materials shall be provided with insulated fittings. All piping showing leaks on test shall be taken down and the joints shall be remade.

Connections between ferrous and nonferrous metallic pipe shall be made with dielectric unions or flanges having metal parts separated to prevent current flow between dissimilar metals.

Piping shall have burrs removed and shall be rattled and cleaned of loose dirt and scale before erection. Open ends of piping and equipment connections shall be plugged or capped during erection. Temporary strainers shall be provided in systems and removed after flushing operation is performed. Low points of the systems shall be provided with hose end adapters for draining systems.

The Plumbing Contractor shall have a journeyman present at all times while General Contractor is either pouring concrete or constructing masonry walls to insure proper installation of work in this Contract.

**VALVES:**

Valves shall be provided at risers and main branches at point of takeoff from their supply or return mains, at inlets and outlets of individual equipment units, and where indicated and/or specified. Valves shall not be installed with stem below the horizontal. Install shut-off valves on all hot and cold water branches serving more than one fixture.

Ball valves shall be used in piping up through 2". Acceptable ball valve manufacturers are Apollo (No. 70-200), Watts (No. B-6001), Nibco (No. S580), and Grinnell. Ball valves shall have brass or bronze body and ball, lever handle, teflon seats and seal, and rated up to 200 psig at 250°F.

Gate or Butterfly valves shall be used in piping 2-1/2" and larger. Acceptable valve manufacturers are Grinnell, Jenkins and Hammond. Gate valves submitted for approval shall comply with MSS Standard SP-80 for bronze valves.

**UNIONS:**

Unions shall be bronze 150 lb. type for copper pipe applications manufactured by Mueller, Crane, Northern Indiana Brass, or approved equivalent. Unions shall be installed at each valve and at frequent intervals in each main run of pipe to facilitate removal and repair of pipe, fixtures and appurtenances.

**WATER HAMMER ARRESTORS:**

The flow velocity of the water distribution system shall be controlled to reduce the possibility of water hammer. A water hammer arrestor shall be installed where quick-closing valves are utilized and where indicated on the drawings. The arrestor shall be located within an effective range of the quick-closing valve. Water hammer arrestors shall conform to AWWA, ASME A112.26.1 or ASSE 1010 listed in chapter 19. Access shall be provided to water hammer arrestors. Approved manufacturers are Watts, Smith, and Zurn.

**PIPE SLEEVES:**

Install pipe sleeves and properly secure in place at all points where pipes pass through floors, walls, or ceilings. Pipe sleeves shall be of sufficient diameter to provide approximately 1/4 inch clearance around insulation. Pipe sleeves in walls, floors, and partitions shall be Schedule 40 black steel . Caulk annular space between pipes and insulation and sleeves, both sides, with an elastic fire-resistant compound.

**PIPE HANGERS AND SUPPORTS (see also Section 15060):**

Pipe hangers and supports shall be of a size to support water filled piping with a safety factor of 5 based on hanger or support ultimate tensile strength. Hangers and supports shall be manufactured by PHD, Grinnell, B-Line Systems, or Pipe Shields, Inc. Size hangers for all insulated piping to fit over insulation with an acceptable clearance.

Hangers for hot water piping shall be equal to Grinnell Fig. 181. Vertical pipes shall be supported by wall brackets equal to Grinnell Fig. 261. Piping hanger and support installation shall allow for uniform expansion and contraction at all times. Provide 8" long 16 gauge sheet metal saddles extending 120° around bottom of insulated pipe.

**PIPE INSULATION:**

Insulate all hot and cold water piping. Insulation shall be a jacketed glass fiber pipe covering, 1" thick for pipe sizes 2" & less, 1½" thick for pipes 2½" & above, with flame resistant vapor barrier jacket meeting ASTM E84 and UL 723. Insulation shall be Knauf 850 or equal by Owens-Corning or Schuller. Provide PVC pre-formed jacket covers over insulated fittings such as elbows, tees, valves, etc. and over all domestic water piping in boiler room.

**INSULATION INSTALLATION:**

Install insulation per manufacturer's recommendations. All insulation shall be installed in a workmanlike manner by qualified workers in the regular employ of the Contractor.

All insulation shall be applied to clean, dry surfaces butting all sections firmly together and finishing as specified hereinafter. All vapor barriers shall be sealed, and shall be continuous throughout. No staples shall be used on any vapor barrier jacket. All vapor barriers shall be of the fire retardant type.

Insulation of all insulated lines shall be interpreted as including all pipe, valves, fittings, and specialties comprising the lines, except flanged unions and screwed unions on hot piping. Insulation over fittings shall be of equal thickness as the adjoining pipe insulation . Unless otherwise specified or directed, insulation for fittings and flanges shall be of the permanent type.

Support of pipe shall be on the outside of the insulation. The insulation at each support shall be rigid and of an equal thickness and finish as the adjoining pipe insulation; the length to coincide with the saddles.

**CLEANING:**

All surfaces on metal, pipe, insulation covered surfaces, and other equipment furnished and installed under this section of the specifications shall be thoroughly cleaned of grease, scale, dirt and other foreign materials, and new equipment shall have a coat of first-class primer.

**CHLORINATION:**

Before Owner occupies building, all water piping installed under this section including shall be sterilized with chlorine. This shall be accomplished by the introduction of a chlorinating material into the lines in such



quantity that the water in the lines shall contain not less than 50 parts per million of available chlorine. The chlorinating material shall be either liquid chlorine or sodium hypochlorite solution, and shall be introduced into the system in an approved manner. The sterilizing solution shall be allowed to remain in the system for a period of two hours during which time all valves and faucets shall be opened and closed several times. After sterilization, solution shall be flushed from the system with clear water until no residual chlorine remains, after which a sample shall be collected for bacterial analysis.

The entire sterilization procedure shall be in strict accordance with the requirements of the State Board of Health and, upon completion of the sterilization, the potability of the water in the system shall be checked and approved by the County Health Department.

Prior to final Payment Application, provide Engineer two copies of the Bacteriological Analysis Report for water samples taken at source and at a general tap and tested for coliform and chlorine residuals.

**PRESSURE TESTING:**

Test all piping and connections installed under this contract. Do testing prior to painting, backfilling, insulating or concealment within building construction. Trenches may be backfilled prior to pressure tests, but not before work has been visually inspected by the Owner. If pressure tests indicate leaks in piping, it shall be the Contractor's responsibility to determine location of leaks, excavate as required, repair leaks, and backfill at his expense.

Perform each test as specified hereinafter and continue or repeat until the lines under test are proven tight to the satisfaction of the Owner. Furnish all materials, pumps, gauges, plugs, etc., required for tests. Notify the Engineer in advance of tests so he may witness same.

Sections of the system may be tested separately, but when so tested, any defect which may develop in a section already tested and accepted shall be corrected and that section re-tested. Devices or equipment which may be harmed by test pressures shall be removed or protected during tests. After testing, test systems for complete drain-ability by draining all water from piping using permanent caps, plugs, drain valves, etc. Test building water piping at 125 psig for a minimum of 4 hours before it is witnessed by Engineer, then for an additional 24 hours. Water test all exterior water mains at 125 psig.

**ACCESS PANELS AND ENCLOSURES:**

Provide access panels and / or enclosures at all locations required to service inaccessible valves, hair interceptors, filters, cleanouts, etc. Access panels in finished spaces shall be stainless steel. Acceptable manufacturers include Karp, Elmdor or approved equal.

**HEAT TRACING:**

Furnish and install UL approved self-regulating heat tracing cable for freeze protection of all water piping outside insulation envelope including backflow preventer systems. The heat trace cable shall consist of two (2) 16 AWG nickel plated copper bus wires embedded parallel in a self-regulating polymer core that varies its power output in response to temperature along its entire length. The heat trace jacket shall be a radiation cross linked polyolefin dielectric rated at 300 VAC at 105°F with a VW-1 flame resistance and shall have a outer braid of tinned copper for a ground path.

Heat trace shall be installed in strict accordance with manufacturer's instructions after pressure testing and immediately before pipe insulation. The heat trace shall be resistance tested by a licensed Electrician at the expense of the Plumbing Contractor. Trace system shall be connected to GFCI protected power by the Electrical Contractor, at the expense of the Plumbing Contractor.

Domestic water heat trace cable shall be Model HSX-A-120V manufactured by Thermon or equal by RayChem.

PIPE AND VALVE IDENTIFICATION:

Furnish and install flexible, permanent, color-coded, plastic-sheet pipe markers that comply with ANSI A13.1 on all exposed piping (including piping above lay-in ceiling) not to exceed 10' o.c., equal to Seton SetMark pipe markers.

Furnish and install brass valve tags with 1/4" high letters identifying operation / maintenance of piping system, equal to Seton No. M4506.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**GENERAL:**

Furnish and install a complete sanitary drain, waste and vent system as shown on the drawings and as specified herein.

No waste or vent piping buried below slab shall be smaller than 2". Make any change in flow direction or grade gradually with proper curved fittings. Make all junctions with wye branches or wye and eighth bend. Sanitary tees may be used for vertical junctions. Size pipe per drawings.

Keep piping clean during construction. Seal all clean-outs and fixture connections. Remove all earth or foreign matter. Bed, fill and compact all line trenches according to Section 15150 or as detailed on the plans to prevent strain on joints, damage or settling.

Set all water closet fittings, floor drains, clean-outs, etc., carefully, using a spirit level. Confirm final floor elevations. The Plumbing Contractor shall have a journeyman present at all times while General Contractor is pouring concrete to insure proper installation of work in this Contract.

Install all piping with 1/4" per foot slope wherever possible but with minimum slopes as follows: 3" and less - 1/4" per foot; 4" and larger - 1/8" per foot.

**DRAIN, WASTE AND VENT PIPING BELOW SLAB:**

Construct all building sewers and building drain lines below floor slabs and outside of building walls, unless indicated otherwise on the drawings, with Schedule 40 PVC-DWV Pipe, ASTM D-2665, marked to indicate that it complies with this standard. Pipe shall be manufactured by Charlotte Pipe and Foundry or equivalent. All installations shall conform to installation instructions of the Plastic Pipe Institute, manufacturer, and/ or local ordinances. In all cases, approved cleaner, primer and solvent cement designated for the specified material shall be used.

**DRAIN, WASTE AND VENT PIPING ABOVE FLOOR SLAB:**

All waste and vent piping above the floor slab shall be Schedule 40 PVC-DWV in accordance with Commercial Standards CS272-65, or CS270-65, or ASTM Standards D2665-68 or D2661-67. All plastic pipe and fittings shall bear the NSF Seal of Approval, and such other markings as required by the aforementioned standards. Fittings shall be molded, fully recessed, socket type designed for solvent welded joints. All plastic piping shall be installed and joined in strict accordance with the pipe manufacturer's instructions. Plastic waste and vent pipe shall not be used in any return air plenum unless it is fully encased in a fireproof covering or as required by any code.

**DRAIN AND WASTE PIPING BELOW SLAB IN KITCHEN:**

Drain and waste piping under slab in kitchen areas that is subject to water temperatures above 120F (Dishwasher Discharge, 3 Compartment Sink Discharge, Steam Equipment Discharge, Tilt Skillet drain, etc.) shall be Hub & Spigot cast iron pipe for a minimum of 30 feet before transitioning to PVC.

**DRAIN AND WASTE PIPING EXPOSED IN KITCHEN:**

Drain and waste piping exposed under kitchen sinks, dishwashers, etc. shall be 2" brushed finish stainless steel pipe. Support from equipment or floor with stainless supports per manufacturer written instructions.

**TRAPS:**

Provide each fixture with a trap when connection to drainage system is required. Place each trap as near to fixture as possible. No fixture shall be double trapped.

**PIPE STORAGE:**

If possible, pipe should be stored inside. Otherwise, store pipe on dry, level ground free from sharp objects. Protect stored pipe from ultraviolet exposure as required. Refer to manufacturer's recommendations for rack or pallet storage and freezing temperatures.

**PIPE HANGERS AND SUPPORTS:**

Support Schedule 40 PVC- DWV pipe with carbon steel adjustable clevis-type hangers, 5' o.c. with 3/8" threaded rod. Chain, strap, perforated bar, or wire hangers will not be permitted. Where required, provide suitable concrete inserts in masonry or concrete during laying or placing of those materials. Acceptable manufacturers are B-line, PHD, Gulf State Hangers, and Grinnell.

**PIPE SLEEVES:**

Provide pipe sleeves where all pipe passes through floors, utility platforms, walls, roofs, etc. Size sleeves for insulated pipe to accommodate both pipe and insulation. Sleeves for piping masonry or concrete walls, floors, beams, or roof, shall be of black steel pipe of standard weight, unless otherwise specified or shown. Vertical sleeves through floors shall extend at least 1" above finished floor (4" through utility platforms).

**ROOF VENT FLASHING:**

Vents through roof shall be flashed with 4 lbs. lead or 16 oz. copper extending 12" each way from the vent. Provide lead collar, soldered to, and extending from flashing up, around, and turned down a minimum of 1" into top of vent.

**CLEAN-OUTS:**

Provide clean-outs at the base of all plumbing stacks, 2'-0" above finish floor if required by local codes; at all changes in direction of all sewers; and wherever indicated on the drawings.

All cleanouts shall be as manufactured by Smith, Josam, or equal by Zurn.

**FLOOR, WALL, AND CEILING PLATES:**

Where pipes pass through floors, finished walls or ceilings, fit with chromium plated cast brass plates or chromium steel plates as specified hereinafter. Plates shall be large enough to completely close hole around pipes, and shall be square, octagonal, or round, with least dimension not less than 1.5 times larger than diameter of pipe. Secure plates in an approved manner. Plates shall be Beaton-Caldwell No. 3A for floor and No. 40 for walls and ceilings.

**PRESSURE TESTS:**

The engineer shall be notified several days before testing is to be conducted and all tests shall be conducted in presence of engineer. Prior to notifying the engineer, the Contractor shall have successfully tested the piping. The Contractor shall bear the expense of the engineer's services if the tests prove unsuccessful after the engineer has been summoned by the Contractor to observe the test.

Water test all interior soil, waste, vent, and drain piping with 10' head pressure before connecting to exterior sewers and before connecting to fixtures. Water shall remain in each system for at least 4 hours. Leaks shall

be repaired and tests repeated until system fulfills this test. Systems may be tested in sections, but each joint between sections shall be tested. Do not exceed 25' head pressure on any joint.

Water test all exterior sanitary sewers with 4'-0" minimum head (above the invert) at the highest point of the sewer. Infiltration or exfiltration shall not exceed 50 gallons per inch diameter per mile per 24 hours.

Contractor shall use video camera to detect installation deficiencies such as excessive deflections, damaged pipes, leaking joints, etc. Engineer's and / or Owner's representative shall be on site to witness videotaping of all sewer piping. Contractor shall provide two (2) video tapes with corresponding diagrams for Owner's record.

*END OF SECTION*

**PART I: GENERAL**

RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

SUMMARY

- A. This Section includes plumbing fixtures and trim, faucets, other fittings, and related components.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
  - 1. Division 7 Section "Joint Sealants" for sealing between fixtures and walls, floors, and counters.
  - 2. Division 15 Section "Valves" for general-duty valves used as supply stops.
  - 3. Division 15 Section "Plumbing Specialties" for backflow preventers and other specialties not specified in this Section.

DEFINITIONS

- A. Accessible: Plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped, disabled, and elderly people.
- B. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, showerheads and tub spouts, drains and tailpieces, traps and waste pipes. Pipe fittings, tube fittings, and general-duty valves are included where indicated.

SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data for each plumbing fixture category and type specified. Include selected fixture, trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.
- C. Provide wiring diagrams from manufacturer for electrically operated units.
- D. Maintenance data for plumbing fixtures and components to include in the operation and maintenance manuals specified in Division 1.

QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category from one source and by a single manufacturer. Exception: Where fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for this category.
- B. Regulatory Requirements: Comply with requirements of CABO A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; regarding plumbing fixtures for physically handicapped people.
- C. Regulatory Requirements: Comply with requirements of Architectural and Transportation Barriers Compliance Board's (ATBCB) "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" regarding plumbing fixtures for physically handicapped people.

- D. Energy Policy Act Requirements: Comply with requirements of Public Law 102-486, "Energy Policy Act," regarding water flow rate and water consumption of plumbing fixtures.
- E. Listing and Labeling: Provide electrically operated fixtures and components specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
  - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Product Options: Drawings indicate size, profiles, dimensional requirements, and characteristics of plumbing fixtures and are based on specific types and models indicated. Other manufacturers' fixtures with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

#### DELIVERY, STORAGE, AND HANDLING

- A. Deliver plumbing fixtures in manufacturers protective packing, crating, and covering.
- B. Store plumbing fixtures on elevated platforms in dry location.

#### PROJECT CONDITIONS

- A. Field Measurements: Coordinate roughing-in and final fixture locations and verify that plumbing fixtures can be installed to comply with original design and referenced standards.

### **PART II: PRODUCTS**

#### PLUMBING FIXTURE STANDARDS AND ACCESSORIES

- A. Comply with applicable standards below and other requirements specified.
  - 1. Refer to the Specifications and Drawings for specific catalog numbers and required fittings.
  - 2. Fixture Manufacturers:
    - a. Vitreous China Fixtures: Kohler, American Standard, or Crane.
    - b. Stainless Steel Sinks: Elkay, Just Mfg. Co., Acorn, or Moen.
    - c. Electric Water Coolers: Oasis, Sunroc, Murdock, or Halsey-Taylor.
    - d. Janitor's Receptor: Fiat, Stern-Williams, or Creative Industries.
    - e. Kitchen Stainless Steel Sinks: Elkay, Just or Moen.
  - 3. Fittings Manufacturers:
    - a. Flush Valves: Sloan, Zurn or Delany.
    - b. Water closet Seats: Water closet manufacturer, Olsonite or Church.
    - c. Faucets: Delta, Zurn or Kohler.
    - d. Supplies and Stops (Loose Key): McGuire Mfg. Co., Dearborn, EBC or T&S.
    - e. Traps: McGuire Mfg. Co., EBC, Central Brass, or Dearborn.
    - f. Shower Controls: Symmons, Leonard or Acorn.

### **PART III: EXECUTION**

#### EXAMINATION

- A. Examine roughing-in for potable, hot- and cold-water supply piping systems; soil, waste, and vent piping systems; and supports. Verify that locations and sizes of piping and locations and types of supports

match those indicated, before installing and connecting fixtures. Use manufacturers roughing-in data when roughing-in data are not indicated.

- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Do not proceed until unsatisfactory conditions have been corrected.

#### PLUMBING FIXTURE INSTALLATION

- A. Assemble plumbing fixtures and trim, fittings, faucets, and other components according to manufacturers' written instructions.
- B. Install fixtures level and plumb according to manufacturers' written instructions, roughing-in drawings, and referenced standards.
- C. Install floor-mounted, floor-outlet water closets with closet flanges and gasket seals. Install wall-hanging, back-outlet water closets with carrier and support manufacturers tiling frame or setting gage.
- F. Install wall-hanging, back-outlet urinals with gasket seals.
- G. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for handicapped people to reach.
- H. Fasten Wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated. Fasten floor-mounted fixtures to substrate. Fasten fixtures having holes for securing fixture to wall construction, to reinforcement built into walls. Fasten recessed, wall-mounted fittings to reinforcement built into wall. Fasten wall-mounted fittings to reinforcement built into walls. Fasten counter-mounting plumbing fixtures to casework.
- M. Set mop basins in leveling bed of cement grout.
- N. Secure supplies to supports or substrate within pipe space behind fixture.
- O. Install an individual loose key stop valve in each water supply to fixture. Install loose key water-supply stop valves in accessible locations. Turn loose keys over to owner at project close out.
- Q. Install faucet, laminar-flow fittings with specified flow rates and patterns in faucet spouts when faucets are not available with required rates and patterns. Include adapters when required. Install supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.
- S. Install faucet, flow-control fittings with specified flow rates and patterns in faucet spouts when faucets are not available with required rates and patterns. Include adapters when required.
- T. Install shower, flow-control fittings with specified maximum flow rates in shower arms.
- U. Install traps on fixture outlets. Omit traps on fixtures having integral traps. Omit traps on indirect wastes, except where otherwise indicated.
- V. Install escutcheons at wall, floor, and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons where required to conceal protruding pipe fittings.
- W. Seal joints between fixtures and walls, floors, and counters using sanitary-type, 1 -part, mildew-resistant, silicone sealant according to sealing requirements specified in Division 7 Section "Joint Sealant." Match sealant color to fixture color; provide white, unless noted on drawings otherwise.



**PART IV: COMMISSIONING**

**CONNECTIONS**

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
  - 1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other Division 15 Sections.
- B. Supply and Waste Connections to Plumbing Fixtures: Refer to plumbing fixture schedules at the end of this Section for fitting sizes and connection requirements for each plumbing fixture.
- C. Supply and Waste Connections to Equipment Specified in Other Sections: Connect equipment with supply inlets, supply stops, supply risers, and traps specified in this Section. Use fitting sizes required to match connected equipment. Connect fittings to plumbing piping.
- D. Ground equipment.
  - 1. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. Where manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.
- E. Arrange for electric power connections to fixtures and devices that require power. Electric power is specified in Division 16 Sections.

**FIELD QUALITY CONTROL**

- A. Verify that installed fixtures are categories and types specified for locations where installed.
- B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized and demonstrate proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

**ADJUSTING AND CLEANING**

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Operate and adjust disposers, hot-water dispensers, and controls. Replace damaged and malfunctioning units and controls.
- C. Adjust water pressure at drinking fountains, electric water coolers, faucets, shower valves, and flushometer valves having controls, to produce proper flow and stream.
- D. Replace washers and seals of leaking and dripping faucets and stops.
- E. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Include the following:
  - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
  - 2. Remove sediment and debris from drains.

PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities, except when approved in writing by Owner.

*END OF SECTION*

**PART I - GENERAL**

RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

SUMMARY

- A. This Section includes Plumbing Specialties for water distribution systems; and soil, waste and vent systems.

SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Submit product data including rated capacities of selected models and weights (shipping, installation, and operation). Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections.

**PART II - PRODUCTS**

MANUFACTURERS

- A. Acceptable Manufacturers:
  - a. Backflow Preventers:
    - i. Ames Co., Inc.
    - ii. Hersey Products, Inc., Grinnell Corp.
    - iii. Watts Regulator Co.
    - iv. Wilkins Regulator Div., Zurn Industries, Inc.
  - b. Water Pressure Regulators:
    - i. Spence Engineering Co., Inc.
    - ii. Watts Regulator Co.
    - iii. Wilkins Regulator Div., Zurn Industries, Inc.
  - c. Specialties:
    - i. Josam Co.
    - ii. Smith by Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
    - iii. Watts Regulator Co.
    - iv. Woodford Manufacturing Co. Div., WCM Industries, Inc.
    - v. Zurn by Hydromechanics Div., Zurn Industries, Inc.

#### CLEANOUTS

- A. Exterior Surfaced Areas: Round cast nickel-bronze access frame and non-skid cover.
- B. Exterior Un-Surfaced Areas: Line type with lacquered cast iron body and round epoxy coated gasketed cover.
- C. Interior Finished Floor Areas: Lacquered cast iron, two-piece body, round with scoriated cover in service areas and round with depressed cover to accept floor finish in finished floor areas.
- D. Interior Finished Wall Areas: Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless-steel access cover secured with machine screw.

#### WATER HAMMER ARRESTORS

- A. ANSI A112.26.1; sized in accordance with PDI WH-201, pre-charged suitable for operation in temperature range -100 to 300 degrees F and maximum 250 psig working pressure.

#### TRAP SEAL PRIMER VALVE:

- A. ASSE 1018; water supply fed type, fully automatic 125psig minimum working pressure, Bronze body with atmospheric vented drain chamber, ½ inch threaded or solder joint inlet and outlet connections, Chrome plated, or rough bronze finish. Unit shall be capable of being located on any active water line.

#### BACKFLOW PREVENTERS

- A. Reduced Pressure Back-flow Preventers: ANSI/ASSE 1013; bronze body with bronze and plastic internal parts and stainless-steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve which opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

### **PART III - EXECUTION**

#### PREPARATION

- A. Coordinate construction areas to receive drains to the required invert elevations.

#### INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
- B. Extend clean-outs to finished floor. Lubricate threaded clean-out plugs Teflon pipe dope. Ensure clearance at clean-out for rodding of drainage system.

- C. Encase exterior clean-outs in concrete flush with grade.
- D. Install water hammer arrestors complete with accessible isolation valve.

*END OF SECTION 15430*

**PART I - GENERAL**

**DESCRIPTION:**

Domestic water heater system complete, ready for operation including water heaters, thermometers and all necessary accessories, connections and equipment.

**1.2 RELATED WORK:**

- A. Section 15000, GENERAL PROVISIONS (MECHANICAL).
- B. Piping, Fittings, Valves and Gages: Section 15400, PLUMBING FIXTURES.
- C. Preparation and finish painting Section 09900, PAINTING.
- D. DIVISION 16

**1.3 QUALITY ASSURANCE:**

- A. Comply with American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE) for efficiency performance, ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings, "for commercial water heaters."

**1.4 SUBMITTALS:**

- A. Submit manufacturer's literature and data pertaining to the water heater in properly bound package, in accordance with Section 01340, SAMPLES AND SHOP DRAWINGS. Include the following as a minimum:
  - 1. Water Heaters.
  - 2. Pressure and Temperature Relief Valves.
  - 3. Steam Control Valves.
  - 4. Thermometers.
  - 5. Pressure Gages.
  - 6. Vacuum Breakers.

**1.5 APPLICABLE PUBLICATIONS:**

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standard Institute (ANSI):
  - Z21.10.1-98..... Gas Water Heaters
  - Z21.18-95..... Gas appliance Pressure Regulators
  - Z21.20-93..... Automatic Gas Ignition Systems and Components
  - Z21.21-95..... Automatic Valves for Gas Appliance
  - Z21.22-99..... Relief Valves for Hot Water Supply systems
- C. American Society Of Mechanical Engineers (ASME):
  - B1.20.1-83(R 1992) ..... Pipe Threads, General Purpose
  - B16.5-96 ..... Pipe Flanges and Flanged Fittings
  - B16.24-91(R 1998) ..... Cast Copper Alloy Pipe Flanges
  - PTC 25.3-94..... Pressure Relief Devices
  - Section IV-98 ..... Heating Boilers

- Section VIII-98 ..... Pressure Vessels Division 1
- D. National Fire Protection Association (NFPA)
- 54-99 ..... National Fuel Gas Code
- 70-99 ..... National Electric Code
- E. Underwriters Laboratories, Inc. (UL):
- 174-1996 ..... Household Electric Storage Tank water Heaters
- 1453-1994 ..... Water Heaters, Electric Booster and Commercial Storage Tank

## **PART 2 - PRODUCTS**

### **2.1 ELECTRIC WATER HEATERS:**

- A. Tank Construction: Steel shell, glass lined, and ASME-Code construction with 1035 kPa (150 psig) working pressure rating.
- B. Tapping (openings): Factory fabricated of materials compatible with the tank and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required.
- C. Insulation: Comply with ASHRAE 90.1.
1. 2 inch and smaller: Threaded ends according to ASME B1.20.1.
  2. 2 1/2-inch and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B 16.24.
- D. Heating Element: double element, immersion type, thermostatically adjustable. Set thermostat for maximum water temperature of 120 degrees F. Phase and voltage as shown on the drawings.
- E. Combination Pressure and Temperature Relief Valves: ASME rated, constructed of all brass or bronze with a self-closing reseating valve. Pressure setting shall be less than water heater working pressure, and relieving capacity shall not be less than heat input.
- F. Electrical power requirements: Field coordinate power connect requirements with E.C. prior to ordering equipment. Provide 120/208/240V or 277/480V as required to match electrical feeders.
- G. Provide water heat as manufactured by: Rudd, Rheem, State, A.O. Smith or equal. See schedule on plans for specific heater requirements.

### **2.2 GAS TANK TYPE WATER HEATERS:**

- A. Comply with ANSI Z21.10.1
- B. Tank Construction: Steel, glass lined, with 1035 kPa (150 psig) working pressure rating.
- C. Tapping (Fittings): Factory fabricated of materials compatible with the tank and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls as required, unless noted otherwise:
1. 50-mm (2 inch) and smaller: Threaded ends according to ASME B1.20.1.
  2. 65-mm (2 1/2-inch) and larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B 16.24.
- D. Burner: Natural or LP gas-fired:
1. Thermostatically adjustable.
  2. High temperature limit and low water cutoff devices for safety controls.

3. Automatic ignition in accordance with ANSI Z21.2.
4. Automatic damper in accordance with ANSI Z21.66.
- E. Flue: Provide each heater with number 0.85 mm thick (22 gage) galvanized iron flue of same size as heater outlet, extending from heater to chimney, unless detailed otherwise .
- F. Temperature Setting: Set thermostat for a maximum water temperature of 120 degrees F.
- G. Insulation: Comply with ASHRAE 90.1.
- H. Combination Pressure and Temperature relief Valve: ANSI Z21.22 rated, constructed of all brass or bronze with a self-closing reseating valve.

### **2.3 GAS TANKLESS WATER HEATERS:**

- A. Standards & Guidelines:
  1. Energy Star – 97% Efficient
  2. ANSI Z21.10.3
  3. SCAQMD – 20 PPM NOx emission
  4. Uniform Energy Factor (UEF) – 0.93
- B. Construction: Unit shall have an internally mounted primary and secondary Stainless Steel condensing type burner, direct vent flue with options for ducted interior or direct vent exterior installation. Unit shall have an integral microprocessor controller with built-in recirculation logic and capable of storing and displaying a history of up to a minimum of 8 diagnostic maintenance/error codes.
- C. Tapping (Fittings): Factory fabricated of materials compatible with the application and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, and controls as required, unless noted otherwise:
  1. 50-mm (2 inch) and smaller: Threaded ends according to ASME B1.20.1.
  2. 65-mm (2 1/2-inch) and larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B 16.24.
- D. Burner: Natural or LP gas-fired: (15,000 up to 199,00 Models)
  1. Thermostatically adjustable.
  2. High temperature limit and low water cutoff devices for safety controls.
  3. Automatic ignition in accordance with ANSI Z21.2.
  5. Automatic damper in accordance with ANSI Z21.66.
- E. Temperature Setting: Set thermostat for a maximum water temperature of 120 degrees F. (Adjustable range of 100 degrees F up to 180 degrees F)
- F. Safeties:
  1. Flame Failure Lockout.
  2. Boiling Protection Lockout.
  3. Thermal Overheat protection.
  4. Internal Freeze Protection.
  5. Blocked Flue Protection.
- G. Combination Pressure and Temperature relief Valve: ANSI Z21.22 rated, constructed of all brass or bronze with a self-closing reseating valve.
- H. Warranty:



- a. Heat Exchanger: 8 Years or 12,000 hours of operation (Whichever occurs first)
- b. Remaining Parts & Components: 5 Years
- c. Labor: 1 Year

#### **2.4 THERMOMETERS:**

Gas and Electric Water Heaters: Straight stem, iron case, red reflecting mercury thermometer approximately 175 mm (7 inches) high, 4 to 115 degrees C (40 to 240 degrees F). Install in hot water pipe close to outlet of tank.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION:**

- A. Install water heaters on concrete base.
- B. Install water heaters level and plumb.
- C. Install and connect water heaters in accordance with manufacturer's written instructions.
- D. Pipe all pressure and temperature relief valves discharge to nearby floor drain, floor sink, or mop sink. If no floor drain, floor sink, or mop sink is available, pipe all pressure and temperature relief valve discharge to the building exterior.
- E. All tank type water heaters shall be provided with and installed in a 6" deep emergency drain pan. Emergency drain pan discharge shall be piped to nearby floor drain, floor sink, or mop sink. If no floor drain, floor sink, or mop sink is available, pipe emergency drain pan discharge to building exterior. Raise tank in pan as required to have proper access to the drain valve.
- F. If water heater is installed in a room with a mop sink, provide and install elevated stand. Stand shall be tall enough such that the bottom of water heater tank is higher than top edge of mop sink basin to facilitate drain piping to mop sink drain. Contractor shall maintain a minimum of 1/4" per foot slope on drain piping. Elevated stand height shall take drain slope into consideration.
- G. Install thermometers on water heater inlet and outlet piping.
- H. Provide and install thermal heat traps as required by current NC Energy Conservation Code.
- I. Provide electric power connections to fixtures and devices that require power using licensed electrician as specified in Division 16 Sections.
- J. Ground equipment - tighten electrical connectors and terminals according to manufacturers published torque-tightening values. Where manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B
- K. Set the thermostats for a maximum setting of 120 degrees F unless noted otherwise.

#### **3.2 LEAKAGE TEST:**

Before piping connections are made, test water heaters with hydrostatic pressure of 200 psi.

Correct any leakage or replace water heater and retest at no additional cost to the Owner.

**3.3 PERFORMANCE TEST:**

Ensure that all of the remote water outlets will have a maximum of 120 degrees F and a maximum of 120 degrees F water flow at all times. If necessary, make all correction to balance the return water system or reset the thermostat to make the system comply with design requirements.

*END OF SECTION*

**GAS SERVICE:**

Contractor shall contact gas utility company to determine the extent of service upgrade is required and include all fees in bid. The Contractor is responsible for coordinating gas service, meter installation, and locations of equipment provided by others.

**GAS PIPING BELOW GRADE:**

Buried gas pipe shall be Schedule 40 black steel with welded fittings, primed and wrapped with approved wrap or tape, and buried a minimum of 18" below finish grade. If approved by local Inspector and Utility Company, Polyethylene Plastic Pipe (PE) conforming to ANSI / ASTM D 2104 standards, as manufactured by Phillips 66 Driscopipe or GUC approval equal, may be substituted. Provide 6" wide utility warning tape, "Warnoline" by Safety Sign Co., or approved equal, 12" below finish grade during backfill operation.

**GAS PIPING ABOVE GRADE AND TESTING:**

Gas pipe above finish grade or floor, 2" or less, shall be Schedule 40 black steel pipe with 150 malleable screwed fittings. Pipe 2 1/2" and over, shall be schedule 40 black steel pipe with welded fittings conforming to ANSI/AWS D 1.1. Gas piping shall be air tested at 60 psig for a minimum of 4 hours or 40 psig for 24 hours and shall be witnessed by Engineer and Building Inspector. Clean, prime, and paint all exposed gas piping OSHA Yellow. At contractor's discretion, press fit pipe fittings rated for natural gas may be used. Press Fit system shall be "Mega Press G" by Viega or an equal system.

**GAS VALVES:**

Gas valves shall be tested and certified by AGA and conform to ANSI 221.15B for natural and for LP gas-air mixtures. Gas valve body shall be semi-steel, with a bolted cover, and flanged ends. Acceptable manufacturers are Nibco, Rockwell or Powell..

**INSTALLATION:**

Installation shall be in accordance with current NFPA Bulletin, American Gas Association, and North Carolina Building Code. Provide shut-off valve, dirt leg, and union at each piece of equipment. Provide pipe hangers/supports at specified intervals in NC Fuel Gas Code. Gas piping installed on the roof shall be supported by a trapezoid shaped rubber base that has an integral galvanized metal "U" channel for securing the piping to the support base. Provide Duralock, Anvil, B-Line or equal.

**CONNECTIONS TO EQUIPMENT:**

Provide gas piping and final connections to all equipment furnished under this contract. Provide rough-ins with shut-off valve to gas-fired HVAC equipment as per manufacturer's directions and dimensioned drawings or as directed by the Mechanical Contractor. Final connections to kitchen equipment shall be responsibility of the equipment supplier. Flexible gas piping shall be used to connect appliance to rigid gas supply in utility chase. Flexible gas piping length shall be limited as required to move appliances for cleaning.

*END OF SECTION*

**PART I: GENERAL**

Furnish and install insulation for hydronic and air distribution systems where shown on plans, and specified below.

**HW PIPE INSULATION:**

Insulate hydronic system piping, fittings, flanges, unions, etc. Insulation shall be a jacketed glass fiber pipe covering, 1.5" thick for pipe sizes 1.5" & less, 2" thick for pipes sizes 2" & above with flame resistant vapor barrier jacket meeting ASTM C547 and UL Classified.

Insulation shall be Knauf Earthwool 1000 or equal by Owens-Corning or Johns-Mansville. Provide pre-formed PVC jacket covers over insulated fittings such as els, tees, valves, etc. and over all piping in boiler room (see below).

**CHILLED WATER PIPE INSULATION:**

Insulate chilled water system piping, fittings, flanges, unions, etc. Insulation shall be a condensation control jacketed glass fiber pipe covering, 1.5" thick for pipe sizes 2 1/2" & less, 2.0" thick for pipes 3" to 4", & 2.5" thick for pipes 5" & above with flame resistant vapor barrier jacket meeting ASTM C547 and UL Classified.

Insulation shall be Knauf Earthwool 1000 or equal by Owens-Corning or Johns-Mansville. Provide pre-formed PVC jacket covers over insulated fittings such as els, tees, valves, etc. and over all piping in boiler room (see below).

**BOILER ROOM PIPE INSULATION COVER:**

Furnish & install pre-formed PVC jacketing over insulated piping & fittings in boiler room equal to Proto Corporation LoSmoke 161°F PVC 25/50 Rated. Provide following colors: HEAT = red, CHILLED WATER = blue, MAKE-UP WATER = DOMESTIC WATER by P.C. = green.

**EQUIPMENT INSULATION:**

Insulate hydronic system equipment including but not limited to chilled water expansion or compression tanks, pumps, storage tanks, heat exchanger vessels, etc. Insulation shall be a cellular block or urethane unicellular type with flame resistant vapor barrier jacket meeting ASTM and UL standards.

**DUCTWORK INSULATION:**

Furnish and install all-service faced duct wrap consisting of a blanket of glass fibers factory-laminated to a reinforced foil / kraft (FRK) vapor retarder facing on all supply, ventilation, and non-lined return air ductwork.

Duct wrap shall comply with NFPA 90 performance standards. Duct wrap insulation shall be Knauf Multi-purpose, 2-3/16" minimum thickness 0.75 lb/cf or 2" thick 1 lb/cf density with installed R-value = 6.0, or approved equal by Owens-Corning or Schuller.

**PART II: EXECUTION**

Install system according to manufacturer's written instructions. Drawings indicate only general arrangement of piping, fittings, and specialties

**PIPE INSULATION INSTALLATION:**

The Contractor shall provide all insulation as required on all piping as specified hereinafter and/or as indicated. All insulation shall be installed in a workmanlike manner by qualified workers in the regular employ of the Contractor.

Install insulation according to manufacturer's instructions.

All insulation shall be applied to clean, dry surfaces butting all sections firmly together and finishing as specified hereinafter. All vapor barriers shall be sealed and shall be continuous throughout. No staples shall be used on any vapor barrier jacket. All vapor barriers shall be of the fire-retardant type.

Insulation of all insulated lines shall be interpreted as including all pipe, valves, fittings, and specialties comprising the lines, except flanged unions and screwed unions on hot piping. Insulation over fittings shall be of equal thickness as the adjoining pipe insulation. Unless otherwise specified or directed, insulation for fittings and flanges shall be of the permanent type.

**PIPE INSULATION PROTECTION:**

Support of pipe shall be on the outside of the insulation. The insulation at each support shall be rigid and of an equal thickness and finish as the adjoining pipe insulation; the length to coincide with the saddles.

**PIPE IDENTIFICATION:**

Furnish and install flexible, permanent, color-coded, plastic-sheet pipe markers that comply with ANSI A13.1 on all chilled, hot, & condensate piping (including piping above lay-in ceiling & visible from utility platform) not to exceed 15' o.c. manufactured by Seton Products, MSI, or equal. Provide directional arrows. Verify verbiage with Engineer, i.e., chilled water supply or return, hot water supply and return, etc.

**DUCT SEALANT:**

Prior to insulating, all duct joints (except gasketed joints), seams and connections shall be sealed with brush-on type water-based sealant equal to United-McGill Duct Sealant. Apply in accordance to manufacturer's instructions and / or recommendations.

**DUCT INSULATION INSTALLATION:**

Before applying duct wrap, sheet metal ducts shall be clean, dry, tightly sealed at all joints and seams as specified, sealant applied and inspected by Engineer.

Duct wrap insulation shall be cut to "stretch-out" dimensions as provided in instructions, and a 2" piece of insulation removed from the facing at the end of the piece of insulation to form an overlapping staple and tape flap.

Install duct wrap insulation with facing outside so that tape flap overlaps insulation and facing at other end of piece of duct wrap. Insulation shall be tightly butted. If ducts are rectangular or square, install so insulation is not excessively compressed at duct corners. Seams shall be stapled approximately 6" on center with outward clinching staples. Where a vapor barrier is required, seal with pressure-sensitive tape matching the facing, either plain foil or PRK backing stock.

Where rectangular ducts are 24" in width or greater, duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18" centers (maximum) to prevent sagging of insulation. Adjacent sections of duct wrap insulation shall be tightly butted with the 2" tape flap overlapping. Where a vapor barrier is required, seal all tears, punctures,

and other penetrations of the duct wrap insulation facing with tape or mastic to provide a vapor tight system.

DUCT LINER:

Removed from Spec, not allowed on this project.

**PART III: WARRANTY**

Manufacturer shall guarantee all insulation as installed to be free from manufacturing defects for a period of one year from startup not to exceed twenty-four months from shipping to job site under normal use.

**PART IV: COMMISSIONING**

Prior to pre-final construction review, Contractor shall repair all insulation tears and damage.

*END OF SECTION*

**PART I: GENERAL**

SCOPE:

Provide all labor, materials, accessories and equipment required to install high efficiency gas boilers complete with associated equipment as shown on the drawings and specified in this document.

**PART II: PRODUCTS**

I. **General Requirements**

- A. Furnish and install packaged, modulating, sealed combustion, power-vented, high efficiency condensing gas-fired boilers with cast aluminum or fully welded 316L stainless steel fire tube that use outside air for combustion.
- B. Install packaged boiler unit(s) according to manufacturer's installation instructions. All work to be done in a neat and workmanlike manner.
- C. Weil-McLean Stainless Vertical Firetube (SVF) packaged boiler(s) capable of burning natural or propane gas. Make and model listed for design standard only, other manufacturers accepted.
- D. Boilers shall have I=B=R Hydronic Institute gross output at 100% fire rate per boiler.
- E. Boilers shall be at least 92% minimum DOE efficient as required by National Energy Conservation Act or ASHRAE 90.1.
- F. Boilers shall be capable of full modulation firing with the following minimum turn down rates:
  - 1. Input below 1,500 MBH: 5 to 1
  - 2. Input 1,500 MBH – 2,000 MBH: 25 to 1
- G. Boilers shall be manufactured by ISO 9001 registered company to conform to Section IV of the ASME Boiler and Pressure Vessel Code.
  - 1. The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed.
  - 2. There shall be a single pressure vessel. Multiple pressure vessels are not acceptable.
  - 3. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Pressure drop shall be no greater than 2.4 psi at 180 gpm.
  - 4. The condensate collection basin shall be constructed of welded 316L stainless steel.
- H. Regulatory Requirements
  - 1. Boilers shall meet or exceed the SCAQD (South Coast Air Quality District of California) Low NOx emission requirement of 40NG/J.
  - 2. Boilers and controls to comply with applicable regulations.
  - 3. Boilers shall meet U.S. Environmental Protection Agency and Department of Energy guidelines for "Energy Star" energy efficiency.

II. **Product**

- A. Preferred boiler manufacturer:
  - 1. Reillo (Array)
- B. Acceptable alternative manufacturers:

1. Weil-McLean Stainless Vertical "SVF"
  2. Lochinvar "Crest"
  3. Patterson-Kelly "Solis"
  4. Fulton "Endura"
- 
3. Other manufacturers' boilers must comply with specifying engineer's requirements, including:
    - (a) Full intent of these specifications, and
    - (b) Provide complete submittal including literature, manuals, and wiring diagrams, fuel piping diagrams, and list of similar installations. The alternate must be of similar size and footprint, piping configuration, clearance requirements and heating surface.
    - (c) Submittal presented to engineer at least seven working days before bid opening for approval. Substitutions are not permitted after contract is awarded.
- C. Boiler Construction
1. Boilers heat exchanger:
    - (a) Fully welded 316L stainless steel, fire tube heat exchanger.
  2. Boilers main components:
    - (a) The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. Two burner/flame observation ports shall be provided. .
    - (b) The boiler shall be supplied with two gas valves designed with negative pressure regulation and be equipped with a pulse width modulation blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The boiler shall operate in a safe condition with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor. The inlet (natural) gas pressure to the boiler gas valve should be a minimum of 4" W.C. and a maximum of 13" W.C. If inlet gas pressure exceeds 13" W.C., a 100% lock-up type gas pressure regulator of adequate size must be installed in gas supply piping and adjusted to prevent pressure in excess of 13" W.C.
    - (c) The single burner shall be a premix design high temperature stainless steel to provide a range of modulating firing rates
    - (d) The integrated control shall increase fan speed to boost flame signal when a weak flame signal is detected during normal operation. A 0 -10 VDC output signal shall control a variable speed boiler pump (pump to be offered by manufacturer) to keep a fixed delta t across the boiler regardless of the modulation rate. The boiler shall have the capability to receive a 0 – 10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues such as erratic temperature cycling.
    - (e) The boiler shall be equipped with a device capable of controlling the air/fuel ratio through the turndown ratio specified on the schedule.



- (f) The boiler shall feature a controller which is standard and factory installed with an 8" liquid crystal touch screen display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities and PC port connection. A secondary control that is field mounted outside or inside the appliance is not acceptable. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The boiler shall have a built-in "Cascade" to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours.
- (g) The boiler shall be capable of controlling an isolation valve (valve shall be offered by manufacturer) during heating operation and rotation of open valves in standby operation for full flow applications. The control must be equipped with standard Modbus communication protocol with a minimum 55 readable points. The boiler shall have an optional gateway device which will allow integration with BacNet (MSTP or IP) or LON protocols as needed to match owner's existing protocol. Verify with owner prior to ordering equipment.

D. Venting and Combustion Air

- 1. Boilers must be capable of using outside air piped directly to boiler for combustion. Inlet and termination of these pipes must be connected as sidewall terminations recommended by the manufacture.
- 2. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the sidewall with the manufacturer's specified vent termination. PVC vent piping may be used in lieu of stainless steel where allowed by the manufacturer's written installation instructions.

E. Boiler Trim

- 1. All electrical components to be high quality manufacture and bear UL label.
- 2. The boiler shall be suitable for use with polypropylene glycol, up to 50% concentration. The de-rate associated with the glycol will vary per glycol manufacturer.
- 3. Water boilers controls furnished:
  - (a) High limit temperature control (190 degrees F maximum allowable boiler water temperature) with manual reset.
  - (b) Combination pressure-temperature gauge. Gauge dial clearly marked and easy to read.
  - (c) ASME certified pressure relief valve, set to relieve at 50 PSI (Standard).
  - (d) Flue gas, outlet water temperature, and return water temperature sensors.
  - (e) Low water protection with manual reset.
  - (f) Outdoor air sensor.
  - (g) High and low gas pressure switches.
  - (h) Built-in freeze protection.
  - (i) 0011 Circulator Pump

F. Boiler Manuals

- 1. The boilers shall be provided with complete instruction manuals, including:
  - (a) Boiler Installation Manual.

- (b) User's Manual.
- (c) Gas Conversion Supplement.
- (d) Venting Supplements and Instructions.

### **PART III: EXECUTION**

#### **INSTALLATION:**

Install system according to manufacturer's written instructions. Drawings indicate only general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in other Division 15 Sections. Install pipe drain to nearest floor drain for overflow and drain piping connections. Install shutoff and check valves on inlet of pressure-operated units. Install inlet strainer and valve bypass to drain at system return connection.

Boiler shall be shipped to job site in heavy-duty crate and protected from elements as required. Boiler shall be placed on 4" high level concrete base. Vent shall be installed in strict accordance with manufacturer's instructions. Pressure relief valve shall be piped to drain with pipe of one size larger than relief valve tapping. Boiler drain outlet shall be piped to the floor drain.

#### **BOILER CERTIFICATE OF INSPECTION:**

Contractor shall contact NC Department of Labor, Boiler and Pressure Vessel Division, for inspection in accordance with NC General Statutes Chapter 95, Article 7A. Contractor shall pay all inspection fees. Provide metal frame with removable glass cover for display of Inspection Certificate in compliance with Uniform Boiler and Pressure Vessel Act of North Carolina.

### **PART IV: COMMISSIONING**

Schedule service of factory trained representative for a period of one day to supervise testing, start-up, and instruction on operation and maintenance to Owner. Contractor shall fire test boilers at operating pressure and temperature in the presence of Owner and / or Engineer to demonstrate proper operation of safety controls.

### **PART V: WARRANTY**

Manufacturer shall guarantee the system as installed to be free from manufacturing defects for a period of one year from startup not to exceed twenty-four months from shipping to job site under normal use. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.

*END OF SECTION*

**PART 1: GENERAL**

1.01 SECTION INCLUDES

- A. Design
- B. Performance Criteria
- C. Controls and control connections
- D. Chilled water connections
- E. Electrical power connections
- F. Chiller Package

1.02 REFERENCES

- A. Products shall be designed, rated and certified in accordance with applicable sections of the following Standards and Codes:
  - 1. To comply with the most recent versions of applicable Standards and Codes of AHRI 550 / 590.
  - 2. AHRI 370 - Standard for Sound Rating of Large outdoor Refrigerating and Air-conditioning Equipment.
  - 3. To comply with the most recent versions of applicable Standards and Codes of ASHRAE 15.
  - 4. Units shall meet the efficiency standards of the latest ASHRAE 90.1 Standard.

1.03 SUBMITTALS

- A. Submit shop drawings and product data in accordance with the specifications.
- B. Submittals shall include the following:
  - 1. Dimensioned plan and elevation view drawings, required clearances, and location of all field connections.
  - 2. Weights and loading document.
  - 3. Product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

1.04 OPERATION AND MAINTENANCE DATA

Include manufacturer's descriptive literature, installation checklist, start-up instructions and maintenance procedure.

1.05 REGULATORY REQUIREMENTS

- A. A. UL 1995 -- Standard for Heating and Cooling Equipment.
- B. Manufactured facility to be ISO 9001.

- C. Factory Functional Test: The chiller shall be pressure tested, evacuated and fully charged with HFC-410A refrigerant and oil. In addition, a factory functional test to verify correct operation by cycling condenser fans, closing compressor contacts and reading data points from temperature and pressure sensors.
- D. Chiller manufacturer shall have a factory trained and supported service organization that is within a 50 mile radius of the site.
- E. Warranty: The manufacturer shall warrant all equipment and material of its manufacture against defects in workmanship and material for a period of one year from date of initial start-up or eighteen months from date of shipment; whichever occurs first.
- F. A 5 year parts and labor warranty shall be provided on any speed increasing or decreasing compressor.
- G. Provide whole unit parts warranty (less motor/transmission/compressor) for the duration of the 1st year.
- H. Provide whole unit labor warranty for the duration of the 1st year.

**1.06 STORAGE AND HANDLING**

- A. Units shall be delivered to job site fully assembled and charged with refrigerant (unless selected with nitrogen charge) and oil by the manufacturer.
- B. Unit shall be stored and handled per manufacturer's instructions.
- C. During shipment, provide protective covering over vulnerable components. Fit nozzles and open pipe ends with enclosures.

**1.07 WARRANTY**

- A. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- B. A 5-year motor/transmission/compressor warranty shall be provided based upon the RPM of the compressors as follows:

<b>Compressor RPM</b>	<b>Warranty Term</b>
0 - 5000	1 year from start-up
5001 - 10,000	5 years from start-up
10,001 and above	5 years plus annual oil analysis

**1.08 MAINTENANCE SERVICE**

Furnish service and maintenance of complete assembly for one year starting from Date of Substantial Completion.

**PART 2: PRODUCTS**

**2.01 ACCEPTABLE MANUFACTURERS**

- A. A. Trane Model CGAM
- B. Carrier 30RB
- C. McQuay AGZ
- D. York YLAA

## 2.02 GENERAL UNIT DESCRIPTION

Factory assembled, single-piece chassis, air-cooled liquid chiller. Contained within the package shall be all factory wiring, piping, controls, and refrigerant charge (HFC-410A or 454B).

## 2.03 COMPRESSORS

- A. Fully hermetic scroll type compressors with R410A or 454B optimized and dedicated scroll profile.
- B. Direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency.
- C. Each compressor shall have overload protection internal to the compressor
- D. Each compressor shall include: centrifugal oil pump, oil level sight glass and oil charging valve.
- E. Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

## 2.04 EVAPORATOR

- B. The evaporator shall be a high efficiency, brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material.
- C. The evaporator shall be protected with an etched foil heater and insulated with 1.5 inch insulation. This combination shall provide freeze protection down to -20F ambient temperatures while the heater is powered. Contractor shall provide separate power to energize heater and protect evaporator while chiller is disconnected.
- D. The water side working pressure shall be rated at 150 psig and tested at 1.5 times maximum allowable water side working pressure.
- E. The refrigerant side working pressure shall be rated at 460 psig (29.6 bars) and tested at 1.1 maximum allowable refrigerant side working pressure.

## 2.05 CONDENSER

- A. The condenser coils shall consist of copper tubes mechanically bonded into plate-type aluminum fins. A subcooling coil shall be an integral part of the main condenser coil.

- B. The maximum allowable working pressure of the condenser shall be 650 psig (44.8 bars). The condensers shall be factory proof and leak tested at 715 psig (49.3 bars).
- C. Low Sound Fans shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise fan blade.
- D. Low speed fan motors shall be three-phase with permanently lubricated ball bearings and individually protected by circuit breakers.
- E. Unit shall be capable of starting and operating at outdoor ambient temperatures from 20F to 125F (-18C - 52C) for all sizes.
- F. Provide factory mounted, louvered, "architecturally pleasing" panels. Panel louvers shall cover the condenser coils and protect from hail.

#### 2.06 ENCLOSURES

- A. Mount starters in a UL1995 rated panel for outdoor use.
- B. The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.
- C. Unit shall have a single point power connection.
- D. A control power transformer shall be factory-installed and factory-wired to provide unit control power.
- E. Control panel shall be dead front construction for enhanced service technician safety.
- F. Power line connection type shall be standard with a terminal block.
- G. Unit wiring shall run in liquid-tight conduit.

#### 2.07 REFRIGERANT CIRCUIT

- A. Chilled fluid circuit shall be rated for 150 psig (1034 kPa) working pressure.
- B. Proof of flow switch shall be provided by the equipment manufacturer and installed the correct number of pipe diameters from any elbow and in the correct orientation.
- C. Flow switch shall be IFM flow monitor type.
- D. Units with brazed plate evaporators shall have a water strainer that is factory provided. It shall be installed with a blowdown valve to facilitate periodic cleaning of the strainer to prevent it from becoming clogged.
- E. Water pipe extensions with insulation shall be factory installed from the evaporator to the edge of the unit.
- F. All major serviceable components shall be located at least 18-inches from edge of chiller. Service shutoff valves and water strainer are conveniently located to enable each service.

2.08 CONTROLS

- A. A. The microprocessor-based unit controller shall be factory-installed and factory-tested.
- B. The unit display shall provide the following data:
  - 1. Water and air temperatures
  - 2. Refrigerant levels and temperatures
  - 3. Flow switch status
  - 4. Compressor starts and run times
  - 5. Display diagnostics.
- C. The unit controller shall provide chilled water reset based on return water as an energy saving option.
- D. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer. Controls shall include the following readouts and diagnostics:
  - 1. Low evaporator refrigerant temperature and/or pressure
  - 2. High condenser refrigerant pressure
  - 3. Low oil flow
  - 4. Motor current overload
  - 5. High compressor discharge temperature
  - 6. Electronic distribution faults: phase loss, phase imbalance, or phase reversal
- E. Unit shall be shipped with factory control and power wiring installed.
- F. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer and a single 115 volt 60 Hz single phase connection for evaporator freeze protection heaters.
- G. The unit controller shall utilize a microprocessor that will automatically take action to prevent unit shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
- H. Provide the following safety controls with indicating lights or diagnostic readouts.
  - 1. Low chilled water temperature protection.
  - 2. High refrigerant pressure.

3. Low oil flow protection.
  4. Loss of chilled water flow.
  5. Contact for remote emergency shutdown.
  6. Motor current overload.
  7. Phase reversal/unbalance/single phasing.
  8. Over/under voltage.
  9. Failure of water temperature sensor used by controller.
  10. Compressor status (on or off).
- I. Provide the following operating controls:
1. Chilled water pump output relay that closes when the chiller is given a signal to start.
  2. High ambient pressure controller that shuts off a compressor to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
  3. Compressor current sensing limit that shuts off a compressor to help prevent current overload nuisance trips.
  4. Auto lead-lag functions that constantly even out run hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor on how to manually change lead-lag on compressors and even out compressor starts and running hours.
  5. Low ambient lockout control with adjustable setpoint.
- J. Provide user interface that displays chilled water temperature setpoint and actual leaving chilled water temperature. Display should be on the front of panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels.
- K. Provide factory installed contact closure input for initiation of ice building. Ice building termination shall be based on an adjustable entering water temperature setpoint. All compressors shall run at full load during ice building.
- L. Digital Communications to BAS system shall consist of a BACnet interface via a single twisted pair wiring.
- M. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- N. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.



- O. The chiller control panel shall provide input for leaving chilled water temperature setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.
- P. The chiller control panel shall provide input for chiller current limit setpoint based upon a 2-10VDC or 4-20mA signal from a building automation system.
- Q. The chiller control panel shall provide an output for chiller Percent Capacity via a 2-10VDC or 4-20mA signal to a building automation system.
- R. On chillers that are going to be located within 20 miles of the coast or are located in a corrosive environment, provide the chiller with a corrosion resistant coating. Coat the condenser coils, components, frame, and all metal portions of the cabinet, interior and exterior. Coating shall meet or exceed ASTM B117 for a 5,000 hour spray rating.

**PART 3: EXECUTION**

**3.01 INSTALLATION**

- A. A. Install in accordance with manufacturer's instructions.
- B. Align chiller package on steel or concrete foundations.
- C. Install units on isolators.
- D. Connect to electrical service.
- E. Connect to chilled water piping.

**PART 4 SEQUENCE OF OPERATIONS:** see drawings.

END OF SECTION

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SYSTEM DESCRIPTION**

The air conditioning system shall be a duct-free electric split system, consisting of a compact, wall mounted indoor fan coil section with remote wall mounted controller and a horizontal discharge outdoor unit with constant speed compressor, charged with R410A or R454B refrigerant.

**WORK INCLUDED**

Duct free split system air conditioning and heat pump units.

**RELATED WORK**

Division 15B  
Division 16

**REFERENCES**

ARI 210 – Unitary Air Conditioning and Air-Source Heat Pump Equipment

**QUALITY ASSURANCE**

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
- C. The units shall be rated in accordance with ARI Standard 210 and bear the ARI label.
- D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 1400-1.
- E. A full charge of R-410A for 100 feet of refrigerant tubing shall be provided in the condensing unit.
- F. A dry air holding charge shall be provided in the evaporator.
- G. System efficiency shall meet or exceed 13.0 SEER.

**Delivery, Storage and Handling**

- A. Unit shall be stored and handled according to the manufacturer's recommendation.
- B. The wired controller shall be shipped inside the carton with the indoor unit and able to withstand 105 F storage temperatures and 95% relative humidity.

**WARRANTY**

The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

**PERFORMANCE**

Each system shall be rated based on 80°F db, 67°F wb for the indoor unit and 95°F db, 75°F wb for the outdoor unit. System efficiency shall meet or exceed 13.0 SEER and shall provide a nominal cooling capacity of 12,000 btuh.

**ACCEPTED MANUFACTURERS**

- A. Daikin
- B. Mitsubishi
- C. Other (By Pre-Bid Substitution Request and Written Approval)

**PRODUCTS**

Indoor Unit:

The indoor unit shall be factory assembled, wired and run tested. All factory wiring, piping control circuit board and fan motor shall be contained within the unit. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes will be charged with dry air instead of R-410A before shipment from the factory. The casing shall have a white finish. Multi-directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard. There shall be a separate back plate to secure the unit firmly to the wall. Return air shall be filtered by means of an easily removable washable filter.

The evaporator fan shall be an assembly with a direct drive line-flow fan, and shall be statically and dynamically balanced. A single motor shall be provided with permanently lubricated bearings. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left or right). A motorized air sweep flow louver shall provide an automatic change in airflow by directing the air up and down to provide for Uniform air distribution. The indoor fan shall consist of two (2) speeds, High and Low.

The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phosphor copper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.

The unit electrical power shall be 115 volts, 1 phase, and 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 103 volts to 127 volts. The indoor unit shall not have any supplemental electrical heat elements.

The unit shall have a wired controller to perform input functions necessary to operate the system. The controller shall consist of an On-Off switch, Cool/Dry-Pan selector, Thermostat setting, Timer Mode, High-Low fan speed, Auto Vane selector, Test Run switching and Check Mode switching. Temperature changes shall be by 2°F increments with a range of 65 - 87°F. The control system shall consist of two (2) microprocessors interconnected by a single non-polar two wire cable. Wiring shall run direct from the indoor unit to the controller with no splices. Manufacturer shall provide (2) 18 Ga. stranded wire conductors for connection to remote controller. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit. Normal operation of the remote controller provides individual system control in which one remote controller and one indoor unit are installed in the same room. The controller shall have the capability of controlling up to a maximum of fifty (50) systems at a maximum developed control cable distance of 1,650 feet. The control voltage from the controller to the indoor unit shall be 12 volts, DC. The control voltage between the indoor unit and the outdoor unit shall be 12 volts, DC. The system shall be capable of automatic restart when power is restored after power interruption. The system shall include self-diagnostics including total hours of compressor run time. The microprocessor within the wall mounted remote controller shall provide automatic cooling, display set point and room temperature, 24 hour on/off timer so that automatic operation function display, check mode for memory of most recent problem. Control system shall control the continued operation of the air sweep louvers, as well as provide on/off and system/mode function switching. The controller shall have the capability to provide sequential starting with up to fifty seconds delay. Two remote controllers can be used to control one unit.

**Outdoor Unit:**

The outdoor unit shall be designed specifically for use with indoor units. The unit shall be equipped with a circuit board that interfaces to the indoor unit and perform all functions necessary for operation. The unit must have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired. Each unit must be run tested at the factory. The casing shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.

The unit shall be furnished with either one or two direct drive propeller type fans. The motor shall have inherent protection, be permanently lubricated bearings. The fan motor shall be mounted for quiet operation. The fan shall be provided with a raised guard to prevent contact with moving parts. The outdoor unit shall have horizontal discharge airflow.

The condenser coil shall be of nonferrous construction with lanced or corrugated plate fins on copper. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of a metering orifice.

The compressor shall be a high performance rotary. A crankcase heater shall be factory mounted on the outside of the compressor. The outdoor unit shall have an accumulator. The compressor will be equipped with an internal thermal overload and high pressure safety switch. The outdoor unit must have the ability to operate with a maximum height difference of without 164 feet and have refrigerant tubing length of 164 feet between indoor and outdoor units. The need for line size changes, traps or additional oil shall be covered by the M.C. The compressor shall be mounted to avoid the transmission of vibration. The outdoor unit shall be capable of operating at 0°F ambient temperature without additional low ambient controls (Optional wind baffle may be required).

The unit electrical power shall be 115 volts, 1 phase, and 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 103 volts to 127 volts. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control voltage between the indoor unit and the outdoor unit shall be 12 volts. DC.

*END OF SECTION*

RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

REFRIGERATION PIPING:

Refrigeration piping shall be seamless ACR hard drawn tempered copper refrigeration tubing, cleaned and capped in accordance with ASTM B-280, with wrought copper long radius fittings manufactured specifically for refrigeration service. Soft copper tubing will be permitted only below grade or inside inaccessible chases.

REFRIGERATION PIPING INSTALLATION:

Refrigeration piping shall be sized in accordance with the H.V.A.C. equipment manufacturer's recommendations. Provide calculations of hot gas discharge and suction line sizing approved by manufacturer with shop drawing submittal. All piping shall be run straight and true as possible with the building structure to prevent compressor lubricating oil from trapping in system.

Braze joints with silver alloy type refrigeration filler rod with 15% silver, 80% copper composition. All joints shall be made with filled with nitrogen. Brazing shall be done by workman certified under ASME "WELDING AND BRAZING QUALIFICATIONS" section IX. All open refrigerant piping shall be capped with plastic seals at ALL times. See Specification Section 15600 for field installed accessories.

TESTING:

Test refrigerant piping using dry nitrogen at 1-1/2 times the operating working pressure for 24 hours without leakage. Brush connections with soap solution for visible bubble test. If no leaks are found, Contractor shall charge system with 20% refrigerant and 80% nitrogen mixture to 200 psig, and perform halide lamp test at all fittings and system connections. System pressure shall be maintained for 24 hours. Upon successful completion of above tests, evacuate system using vacuum pump capable of at least 500 microns mercury absolute and hold for four hours without rise in pressure (with allowable compensation for change in temperature). Apply heat to elbows, loops and low spots during evacuation. Re-charge system in strict accordance with manufacturer's instructions.

If a system leak is discovered, Contractor shall first reclaim existing refrigerant using a refrigerant recovery unit. Venting refrigerant to atmosphere will not be permitted on this project.

INSULATION:

Insulate refrigerant suction pipe with 1/2" thick closed cell rubber pipe insulation, Armstrong AP Armaflex or equivalent prior to making joints. Fabricate mitered covers over elbow fittings. Insulation sections shall be jointed using Armstrong 520 Adhesive. Follow all manufacturers' installation instructions in strict accordance. Splitting insulation or the use of duct tape to join insulation sections will not be permitted on this project. Wrap insulated pipe with 0.016 inch thick embossed aluminum jacketing with longitudinal slip joints, secured with 3/8" wide bands.

REFRIGERATION PIPE SUPPORT:

Provide clevis-type hangers on 10' centers and within 12" of elbows. Liquid line shall be attached to the insulated suction line with nylon clamps or ties at 6' intervals.

*END OF SECTION*

RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

CONDENSATE PIPING:

Condensate piping shall be 1-1/4" diameter minimum PVC pipe and fittings installed in strict accordance with the Plastic Pipe Institute guidelines unless noted otherwise on the drawings. Provide copper or cast-iron piping above corridor ceilings below utility platforms or in similar fire-rated assemblies. Slope pipe a minimum of 1/4" per foot and support with clevis-type hangers at 5'-0" o.c.

INSULATION:

Insulate pipe with 3/8" wall white Polymer foam insulation by IMCOA or 1/2" thick closed cell rubber pipe insulation, Armstrong AP Armaflex or equal by Rubatex, prior to making joints. Fabricate mitered covers over elbow fittings. Insulation sections shall be jointed using Armstrong 520 Adhesive. Follow all manufacturers' installation instructions in strict accordance. Splitting insulation or the use of duct tape to join insulation sections will not be permitted on this project.

PIPE SUPPORT:

Provide clevis-type hangers on 5'-0" centers and within 12" of elbows.

TESTING:

Fill fan coil and air handler condensate pans from utility sinks and allow to flow into storm sewer prior to ceiling installation and pipe insulation. Repair all observed leaks as required.

PIPE IDENTIFICATION:

Furnish and install permanent color-code plastic sheet pipe markers with directional arrows. See also section 15740-4.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SCOPE OF WORK:**

Provide complete systems of piping and fittings for all services, including water system piping, cold water make-up, valves, fittings, joints, hangers, supports, expansion joints, pipe guides, and insulation.

**SUBMITTALS:**

Shop drawings shall be submitted for the following:

- a. piping & fittings
- b. welding procedure & qualification specification
- c. valves / strainers / flow control devices / test plugs
- d. gauges

**BUILDING PIPE INSTALLATION:**

All pipe, valves and fittings shall comply with American Standards Association Code and/or local codes and ordinances (no foreign fittings accepted). Cut pipe accurately to measurements established at building or site, and work into place without springing or forcing, properly clearing all windows, doors and other openings or obstructions. Excessive cutting or other weakening of building to facilitate piping installation will not be permitted. Piping shall line up flanges and fittings freely and shall have adequate unions and flanges so that all equipment can be disassembled for repairs. Test all piping prior to concealing.

All welded pipe and fittings shall be delivered to job with machine beveled ends. Where necessary, beveling may be done in field by gas torch, in which case surfaces shall be thoroughly cleaned of scale and oxidation after beveling. No miter connections will be permitted in welded work.

Screwed piping shall have tapered threads cut clean and true and shall be reamed out clean before erection. Each length of pipe, as erected, shall be upended and rapped to free it of any foreign matter. All piping shall be closed with factory installed caps until prior to installation.

Threaded fittings shall be malleable iron conforming to ANSI B16.3 (150 psig W.O.); welded fittings shall be standard weight Schedule 40 black steel conforming to ASTM A-120. Weld-o-lets may be used in lieu of fitting for branch take-offs from mains 2" or larger provided that the branch take-offs is two or more sizes smaller than the main. No "stub-ins" will be permitted. Threaded joints shall be made with Teflon sealing compound applied to the male threads only.

The Contractor shall coordinate the routing of all piping with other contractors prior to installation. Furnish and install valves as required to allow for complete system drain down.

**ABOVE GROUND PIPING:**

Above ground piping inside building shall be:

Schedule 40 black steel pipe bearing name of manufacturer and weight at regular intervals. Fittings for pipe 2-1/2" and smaller shall be malleable iron 150 lb. screwed and bonded (ASA B16.3). Fittings for pipe 3" and larger shall be welded forged carbon steel (ASTM 234) with same thickness as adjacent piping. Use only long radius elbows. Contractor may choose to use grooved steel piping (Victaulic or Equal) in systems that do not exceed 180F degree water temperatures in lieu of welded steel piping.



Carbon Steel or Copper tubing utilizing a mechanical compression joint (Viega MegaPress, ProPress or Equal) for pipe sizes 4" and less may also be used. *At contractor's option, Aquatherm, Nyrone, or Uponor Non-Metallic piping rated for Hydronic heating & cooling systems may be used in lieu of metallic pipe. See Non-Metallic Hydronic Piping Specification 15740A.*

#### WELDING QUALITY ASSURANCE

Piping shall comply with the provisions of the latest edition of the ASME code for pressure piping, ANSI/ASME B31.1 - Power Piping.

All welding shall be performed by persons currently having an ASME license in accordance with Section IX of the ASME Code. All welding shall be performed in accordance with the North Carolina Boiler Rules. Names, identification stamps, and copy of certification of all welders on job shall be submitted to the Designer and kept for historical purposes in the project files. At the request of the Designer, this contractor shall (at his or her expense) have an independent testing agency test and qualify the welding procedures used in the construction of weldments and the performance of welders who apply these procedures.

At least two weeks before any welding is performed, the Contractor shall submit to the Designer a copy of each welding procedure specification required for the job, together with the procedure qualification record as required by Section IX of the ASME boiler and pressure vessel code.

At least two weeks before any welder shall perform any welding the Contractor shall submit to the Designer a copy of the manufacturer's record of welder or welding operator qualification tests as required by Section IX of the ASME boiler and pressure vessel code.

Welded joints shall be made by first properly beveling the surfaces to be welded, cleaning the mating surfaces, then tack-welding the joint to assure proper alignment prior to completing the weld. Weld metal shall be continuous around the joint and shall be deposited in such a manner that the sides and bottom of the surfaces or edges joined are thoroughly fused with the surface of the weld and have proper reinforcement and width.

The first weld of each welder shall be witnessed and visually inspected and approved by Engineer before further welding by that welder is permitted. Provide at least five (5) working days notice to Engineer.

Weld examination shall be in accordance with ANSI/ASME B31.1 - Power Piping. In addition, the Owner may at any time hire an independent agent to examine the welds using whatever method he or she deems suitable, whether required by ANSI/ASME B31.1 or not.

Any welds not meeting the acceptance criteria of ANSI/ASME B31.1 – Power Piping for the examination technique used shall be repaired in accordance with ANSI/ASME B31.1., at no cost to the Owner.

#### VALVES:

For pipe sizes 3" and larger, valves shall be threaded lug butterfly type, with ductile iron body, teflon or neoprene seat, and bronze disc; Grinnell Series 8000 or equal by Posi-Seal or DEMCO. For pipe sizes 2.5" and smaller, use ball valves non-shock pressure rated up to 400 psi equal to Grinnell Series 3500 with cast bronze body and ball. Soft solder ends at temperatures less than 470°F to prevent damage to seat. Nibco or Apollo shall be considered equal.

Check valves shall be spring loaded, manufactured by Febco, Watts or equal.

#### STRAINERS:

Strainers shall be placed at pumps, coils, chillers, boilers, make-up water and where indicated on the drawings. Strainer body specs shall be same as valves. Screen element shall be rated for 20 mesh/850 microns up to 1-1/2", perforations shall not exceed 1/16" for 2" units and larger.

#### AUTOMATIC FLOW CONTROL VALVES / STRAINERS

Combination automatic flow control valves strainers with pressure and temperature parts shall be installed where shown on the drawings to control the water flow to the scheduled values. These valves shall automatically control the flow of water to the units to within 5% of the indicated flow over a pressure range of not less than 14 times the minimum necessary for proper flow. All internal working parts shall be nickel plated brass or type 300 passivated stainless steel. Where indicated on drawings, provide plug blow down drain, manual air vent, add dielectric union options. See details on drawings. Flow control devices shall be Auto Flow FV-BC/SV-BC by Flow Design Inc. or Flow-ConY, or Ultra-Z by Griswold.

#### TEST PLUGS:

Provide where shown on drawings, 1/4" brass, 1000 psi, 250 degrees F test plugs with Nordel penetrable membrane for measuring pressure and temperature. The plug shall have a firm fitting brass cap. The case shall have a double insert of Nordel to prevent momentary leakage after long periods of penetration. Test plugs shall be manufactured by Peterson Engineering (Pete's plugs) or approved equal.

#### PIPE SLEEVES:

Provide pipe sleeves where pipe passes through floors, beams, walls, roofs, etc. Size sleeves for insulated pipe to accommodate both pipe and insulation. Sleeves for piping masonry or concrete walls, floors, beams, or roof, shall be of black steel pipe of standard weight, unless otherwise specified or shown. Vertical sleeves through floors shall extend at least 1" above finished floor.

#### PIPE HANGERS AND SUPPORTS:

Pipe hangers and supports shall be of a size to support water filled piping with a safety factor of 5 based on hanger or support ultimate tensile strength. Hangers and supports shall be manufactured by B-Line Systems or approved equal by Grinnell or PHD. Size hangers for all insulated piping to fit over insulation with an acceptable clearance.

Clevis hangers for water piping shall be equal to B-Line Fig. 3100. Roller type hangers shall be equal to B-Line Fig B-3110. Vertical pipes shall be supported by wall brackets equal to Grinnell Fig. 261. Hanger rod shall be equal to B-Line Systems Fig B-3205. Pipe insulation protection shield shall be B-Line Fig. 3151. Piping hanger and support installation shall allow for uniform expansion and contraction at all times. Use B-Line Fig. B-3050 or equal universal C-clamps for attachment to structure.

#### PIPE INSULATION:

See Section 15500, Mechanical Insulation.

#### PRESSURE TESTING:

Test all piping and connections installed under this contract. Do testing prior to painting, backfilling, insulating or concealment within building construction. Trenches may be backfilled prior to pressure tests, but not before work has been visually inspected by the Owner. If pressure tests indicate leaks in piping, it shall be the Contractor's responsibility to determine location of leaks, excavate as required, repair leaks, and backfill at his expense.

Perform each test as specified hereinafter and continue or repeat until the lines under test are proven tight to the satisfaction of the Owner. Furnish all materials, pumps, gauges, plugs, etc., required for tests. Notify the Engineer in advance of tests so he may witness same. Sections of the system may be tested separately, but when so tested, any defect which may develop in a section already tested and accepted shall be corrected and that section retested. Devices or equipment which may be harmed by test pressures shall be removed or protected during tests. After testing, test systems for complete drainability by draining all water from piping using permanent caps, plugs, drain valves, etc. Test building water piping at 100 psi for a minimum of 4 hours before it is witnessed by Engineer. Final test system shall be performed at 100 psi for a minimum of 24 hours.

**PIPE AND VALVE IDENTIFICATION:**

Furnish and install flexible, permanent, color-coded, plastic-sheet pipe markers that comply with ANSI A13.1 on all piping (including piping above lay-in ceiling) not to exceed 15' o.c. manufactured by Seton Products, MSI, or equal. Provide directional arrows. Verify verbiage with Engineer, i.e., chilled water supply or return, hot water supply and return, etc. Stencil-type spray-on pipe labels will not be accepted on this project.

Furnish and install brass valve tags with 1/4" high letters identifying operation / maintenance of piping system.

**TEMPERATURE GAUGES:**

Thermometer shall be a dial type, minimum 4.5" diameter black on white dial, stainless case, variable angle mount, copper bulb, with magnifying glass cover. Temperature range shall be 30°F to 240°F (-10°C to 110°C) with a 1% scale range accuracy. Approved manufacturers are Weiss, Terice, Marsh Instruments, and Weksler.

**PRESSURE GAUGES:**

Pressure gauges shall have a minimum 4.5" diameter black on white dial, be stem-mounted, provided with stop locks, have a phosphor-bronze bourdon tube and a corrosion resistant brass movement with a 1% scale range accuracy. Pressure Range shall be selected by Engineer. Approved manufacturers are Terice, Weiss, and Marsh instruments.

**THERMOMETER WELLS:**

Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping and cap nut with chain fastened permanently to thermometer well.

**HEAT TRACING:**

Furnish and install UL approved self-regulating heat tracing cable for freeze protection of all hydronic piping outside insulation envelope (unless system contains antifreeze solution). The heat trace cable shall consist of two (2) 16 AWG nickel plated copper bus wires embedded parallel in a self-regulating polymer core that varies its power output in response to temperature along its entire length. The heat trace jacket shall be a radiation cross linked polyolefin dielectric rated at 300 VAC at 105°F with a VW-1 flame resistance and shall have a outer braid of tinned copper for a ground path.

Heat trace shall be installed in strict accordance with manufacturer's instructions after pressure testing and immediately before pipe insulation. The heat trace shall be resistance tested and connected to GFCI protected power by a licensed Electrician at the expense of the Contractor.

**DIVISION 15B**  
**SECTION 15740**

**HEATING, VENTILATING, AND AIR CONDITIONING**  
**HYDRONIC PIPING SYSTEMS**

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Domestic water heat trace cable shall be Model HSX-A-120V manufactured by Thermon or equal by RayChem.

**ALUMINUM JACKET:**

Furnish and install an aluminum jacket on all piping located on the building exterior or in other places subject to physical damage. Wrap insulated pipe and heat race wiring with 0.016 inch thick embossed aluminum jacketing with longitudinal slip joints, secured with 3/8" wide bands.

*END OF SECTION*

RELATED DOCUMENTS:

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

SCOPE OF WORK:

Contractor shall be responsible flushing, cleaning, and purging of hydronic system piping and pre-treatment of system with corrosion and deposit inhibitors plus microbiocide.

System treatment shall be performed by a competent water treatment company.

Provide a single two gallon chemical bypass feeder, ChemTreat no. 70600880 or Owner pre-approved equal by Dearborn or Calgon.

SYSTEM FLUSHING & PRE-CLEANING:

Clean and flush system before fan coil or air handler connection. After flushing system thoroughly, provide a written certification to Architect that the piping system is free of all dirt, trash, grease, oil, foreign objects, etc.

Make fan coil or air handler connection and clean and re-flush system.

Remove and clean all system strainers then replace.

SYSTEM CLEANING & PRE-TREATMENT PROCEDURE:

1. Check to verify the system has no leaks by whatever method is applicable (visual, hardness test of water from AHU condensate pans, dye, pressure monitoring, make up water meter readings, etc.).
2. Check the PRV and make up bypass valve for proper operation. Purge expansion tank and strainers to remove accumulated rust.
3. Install ball valve on strainers.
4. If the water is dirty:
  - A. Drain and refill until the water clears. Purge air.
  - B. If the water remains dirty after circulation, or if the system must be cleaned while on line, start a running flush (bleed off while make up maintains system pressures) until the water clears. Make sure all control valves are cycled so the entire system is flushed.
5. Add cleaners and inhibitors to the system.
  - A. 5000ppm CT 30 Chill Water Systems (CT 23 may be substituted in hot water systems where there is a minimum of copper in the system).
  - B. 200 ppm CL4123
  - C. 200 ppm CL4400
6. Circulate system for 8-24 hours. During this time, blow down at all low points and deadlegs. Cycle all control valves to make certain the entire system is cleaned. Blow out and / or clean strainers as needed.
7. If the entire system will completely drain by gravity, turn off system. Drain and refill with clean water. Circulate water and start a running flush. If the system will not completely drain by gravity, start a running flush.

8. Continue the running flush until samples collected prior to the make up point to meet the following requirements:
  - A. The pH is less than 9.0.
  - B. The water is clear.
  - C. Iron content is <0.5 or as low as it will go (old systems will not normally be <0.5 after cleaning).
9. Monitor the above parameters frequently. If the iron content rises on two consecutive samples and the water is clear, consider the flushing as complete.
10. Add the appropriate inhibitors:
  - A. CL2871: 4500 ppm – chill water  
6000 ppm – hot water
  - B. NCL2150: 250 ppm – chill water  
250 ppm – hot water (if water will not be >180 degrees F year round)
11. Use and disposal of chemicals and cleaning solutions should comply with appropriate regulations.
12. The system shall have a minimum of each of the following treatments:
  - A. Molybdenum 300 ppm
  - B. Sodium Nitrite 300 ppm
  - C. Tolytriazole 20 ppm

**WARRANTY:**

Schedule water Treatment Company to take water test samples prior to 11 month warranty inspections.

Make corrections and file report to Architect.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I - GENERAL**

Mechanical Contractor shall provide all equipment, labor, and accessories shown on drawings and specified in the following, required to install pumps with capacities as scheduled on the drawings.

**PART II - PRODUCTS**

**BASE MOUNTED, FLEXIBLE COUPLED, END-SUCTION PUMPS:**

- A. Pumps shall be base mounted, single stage, end suction design with an integrally cast, foot mounted volute, capable of the impeller and bearing assembly being serviced without disturbing piping connections, pump volute or motor. The pump and motor shall be mounted on a common base plate of heavy structural steel design and securely welded cross members and open grouting area.
- B. The impeller shall be bronze enclosed, single suction type, dynamically balanced, keyed to the shaft. The allowable residual unbalance in the impeller rotating assembly shall conform to ANSI Grade G6.3.
- C. The liquid cavity shall be sealed off by an internally flushed mechanical seal with ceramic seat of 99.5% pure alumina oxide and hardness of 68 Rockwell C, or a tensile strength of 300,000 PSI, and carbon seal ring, suitable for continuous operation at 225 degrees F. The seals and bearings shall be capable of being serviced without disconnecting the pump from piping or disturbing the volute or motor to maintain original alignment. A replaceable bronze shaft sleeve shall completely cover the wetted area of the shaft under the seal. A stuffing box mechanical seal design with longer span between the impeller centerline and first bearing will not be allowed.
- D. The pump casing shall be of Class 30 cast iron with integrally-cast pedestal support feet, suitable for 175 PSI working pressure. The pump volute shall be supplied with plugged vent, drain, and gauge tappings.
- E. The pump bearings shall be regreaseable ball bearing type with provision for purging or flushing through the bearing surface.
- F. A flexible type, spacer design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupler shall be shielded by an OSHA coupler guard securely fastened to the base.
- G. Motor shall meet EPACT 92 requirements and NEMA specifications and shall be the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned and shall be realigned by mechanical contractor or by an alignment service contractor to factory recommendation.
- H. Pumps shall be capable of withstanding a horizontal load of 0.5 G without adversely affecting pump operation. Pumps used in chilled water applications shall have galvanized drip pans.
- I. Base-mounted end-suction pumps shall be Bell and Gossett 1510 series, Taco FM series, or Armstrong 4030 series.

**IN-LINE PUMPS:**

In-line pumps shall be type for installation in vertical or horizontal piping. Pump must be capable of being serviced without disturbing piping connections.

Pump body shall be class 30 cast iron, rated 175 psi working pressure, with gauge ports at nozzles, and with vent and drain ports. Impeller shall be cast bronze, enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut. The liquid cavity shall be sealed off at the motor shaft by an internally-flushed mechanical seal with ceramic seal seat, and carbon seal ring, suitable for continuous operation at 225° F. A non-ferrous shaft sleeve shall completely cover the wetted area under the seal. Pump bearing bracket shall have oil lubricated bronze journal and thrust bearings. Bracket shaft shall be alloy steel having ground and hardened thrust bearing faces. A flexible coupling to dampen starting torque and torsional vibrations shall be employed. Motor shall meet NEMA specifications and shall be the size, voltage and enclosure called for on the plans. Each pump shall be factory tested. It shall then be thoroughly cleaned and painted with at least one coat of high-grade machinery enamel prior to shipment.

Pumps shall be capable of being serviced without disturbing piping connections. Pumps shall be rated for a minimum of 175 psig working pressure.

Horizontal in-line pump shall be Series 60 as manufactured by Bell and Gossett, or Taco 1600 or VL series, or Armstrong 4300 series.

**TRIPLE DUTY VALVES:**

Furnish and install triple duty valve at system pump designed to perform the functions of a non-slam check valve, throttling valve, shut-off valve and calibrated balancing valve. The valve shall be fitted with a bronze seat, replaceable bronze disc with EPDM seat insert, stainless steel stem and "chatter-preventing" stainless 'S' spring. The valve design shall permit repacking under full system pressure.

The triple duty valve shall be designed for quiet operation. The triple duty valve shall have a non-slam check valve with spring-loaded weighted disc. The unit shall have a calibrated adjustment (multiple turns) for regulation of pump flow. The adjustment shall have "set-memory" position. The unit shall have positive shut-off for servicing the pump. Valve shall be sized equal to pipe branch connection.

The unit shall have gauge tappings at suction and discharge flanges for flow/pressure drop readings using read-out kit. The valve shall be constructed with the body of cast iron, disk and seat of bronze, stem and spring of stainless steel, and the packing of teflon-asbestos. The valve shall be designed to permit repacking while under full line pressure. The valve shall be suitable for 175 psi working pressure.

The valve shall be Bell & Gossett Model No. 3Ds-3S Triple Duty Valve, or Taco Multipurpose Valve or approved equal by Thrush.

**SUCTION DIFFUSERS**

Units shall consist of angle type body with inlet vanes in two planes to assure uniform flow. Units shall have a combination diffuser-strainer-orifice cylinder with 3/16" diameter openings for pump protection. A permanent magnet shall be located within the flow stream and shall be removable for cleaning. The orifice cylinder shall be equipped with a disposable fine mesh strainer which shall be removed after system start-up. Orifice cylinder shall be designed to withstand pressure differential equal to pump shutoff head and



shall have a free area equal to five times cross section area of pump suction opening. Vane length shall be no less than 2 1/2 times the pump connection diameter. Unit shall be provided with pressure gauge tapings to check strainer condition. Unit shall be suitable for 175 psi working pressure. Unit shall be provided with strainer blow-down connection for routine maintenance.

**BRAIDED FLEXIBLE PUMP CONNECTORS:**

Braided flexible metal pump connectors shall be provided on suction and discharge sides of all pumps to absorb vibration, minimize stress and reduce noise.

Flexible metal hose shall be annular, closed pitch hose of 321 stainless steel with 304 stainless steel braid shall be standard. Hose wall thickness for maximum strength and reliability shall be a minimum of .017" for connectors under 1-1/2" and a minimum of .020" for connectors 2" and above. Braid coverage shall be a minimum of 90% to insure maximum operating pressure and an extended cycle life. Pump connector shall have a maximum operating temperature of 1000 degrees Fahrenheit and be able to handle 1/8" misalignment.

**AIR & SEDIMENT REMOVAL SEPARATOR**

The unit shall be capable of air separation and elimination.

The unit shall have tangential inlet and outlet connections to create a low velocity vortex where air and sediments are separated.

The unit shall have a solid separation efficiency of 98% of 200 mesh sand and water solution, and be capable of heavier-than-water, undissolved sediment separation of at least 40 microns. Vessel shell diameter is to be three times the nominal inlet/outlet pipe diameter.

The air separator must be designed, constructed and stamped for 125 psig at 350 degrees F, in accordance with Section VII, Division 1 of the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors.

**EXPANSION TANKS:**

Furnish and install pre-charged vertical (and horizontal under ice storage alternate) steel expansion tanks as detailed on drawings.

The bladder Tank shall be pre-charged, vertical steel expansion tank with replaceable, heavy-duty Butyl rubber bladder. The tank shall have 1 1/2" NPT system connection, a 3/4" NPT drain, and a .302"-32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements. The tank must be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and stamped for 125 psi working pressure. Maximum operating temperature rating shall be 240 degrees Fahrenheit. Tank shall be an ITT Bell & Gossett Series "B" or approved equal.

**PART III - EXECUTION**

**INSTALLATION:**

- A. Install pumps in strict accordance with manufacturer's published instruction manual. Drawings indicate only general arrangement of piping, fittings, and specialties
- B. Piping installation requirements are specified in other Division 15 Sections.
- C. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
- D. The contractor shall level and grout each unit according to the manufacturer's instructions before alignment and start up. Level pump by placing shims under frame as required. Inject non-shrinking grout inside pump base and grout shims.
- E. Support pumps and piping separately so piping is not supported by pumps.
- F. Install shutoff and check valves on inlet of pressure-operated units.
- G. Install inlet strainer and valved bypass to drain at system return connection.
- H. Pull and trim the pump impeller after a proportional balance has been done by the balance contractor. Hydronic systems shall be balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed. A balance report from the installer shall be furnished to the Engineer and a copy included in the operating and maintenance manual.
- I. Electrical power and control wiring, and connections are specified in Division 16 Sections. Install electrical connections for power, controls, and devices. Ground equipment.

**PART IV: COMMISSIONING**

Schedule service of factory trained representative for a period of one day to supervise testing, start-up, and instruction on operation and maintenance to Owner.

Pump manufacturer representative shall verify proper sleeve coupler parallel and angular alignment, record suction and discharge pressure, record amperage draw of motor, and complete name plate data of pump and motor.

**PART V: WARRANTY**

Manufacturer shall guarantee the system as installed to be free from manufacturing defects for a period of one year from startup not to exceed eighteen months from shipping to job site under normal use.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**DUCTWORK:**

Material and thickness: Ducts shall be rectangular and fabricated of prime quality, re-squared, tight-coat-galvanized, steel sheets. All duct construction shall equal or exceed SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure.

**DUCT CONSTRUCTION:**

All ductwork shall be fabricated from prime, number one grade galvanized sheet metal conforming to ASTM A-924-94, G-90. Gauges for duct sizes shall be minimum as follows:

<u>Low Pressure, &lt;1" ESP</u>		<u>Medium Pressure, &lt;2" ESP</u>	
26 Ga.	Up to 30 inches	26 Ga.	Up to 26 inches
24 Ga.	Up to 40 inches	24 Ga.	Up to 30 inches
22 Ga.	Up to 54 inches	22 Ga.	Up to 36 inches
20 Ga.	Up to 96 inches	20 Ga.	Up to 84 inches

Standard flat slips and drives shall be used on ductwork with long dimensions not exceeding 18". On ductwork over 18" standing S cleats, Ductmate angles or equivalent reinforcing shall be used.

Ducts shall have supplemental stiffening as required to prevent drumming and to provide a structurally sound assembly. All ducts except those to which rigid board type insulation is to be applied shall have all sides cross-broken. All duct dimensions shown on drawings are "inside clear". The sizes of acoustically lined ducts shall be increased accordingly. Ducts shall be smooth on inside.

Fabricate all ductwork to prevent seams or joints being cut for installation of grilles, diffusers, or registers. All duct joints and seams shall be fabricated and installed with joints and seams made air tight.

**SPIRAL DUCT:**

Where round duct is indicated on the drawings by diameter, provide spiral duct constructed in accordance with ASHRAE and SMACNA standards, and G-60 galvanized steel meeting ASTM A-517. Duct fittings shall be of welded seam construction, and male fitting slip connection shall be a minimum of 2" from bead to end.

Where exposed duct is detailed on the drawings, provide superior fabrication grade double wall insulated spiral duct with 1" thick insulation meeting NFPA 90A flamespread requirements, welds ground smooth, paintable galvanized steel, perforated liner, and paintable flanged type gasketed duct connection fittings.

Spiral pipe shall be manufactured by United McGill, Hamlin Sheetmetal, Linx Ind, or Spiral Pipe of Texas.

**HANGING DUCTS:**

Support ducts from building structure in accordance with SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure.

**OBSTRUCTIONS AND RESTRICTIONS:**

Where possible, avoid locating any pipe, wire, structural member or other obstruction inside of duct. Take particular care to avoid obstructions in elbows. Where obstruction cannot be avoided, the rules

specified by SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure, shall apply. Where ducts pass through non-rated walls, protect ducts and/or insulation from contact with wall by .5 inch filler of noncombustible material and flange perimeter of wall opening with sheet metal.

**CHANGE IN DUCT SHAPE & DIRECTION:**

Where the area at the end of the transformation results in an increase in area from the beginning of the transformation, the slope of the transformation shall meet SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure.

In general, keep changes in direction and changes in shape to minimum permitted by distribution requirements and building conditions. Make turns with ells, as conditions necessitate, in accordance with SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure.

**SPLITTERS AND/OR HAND DAMPERS:**

Provide splitters or butterfly dampers for adjustment of distribution to respective branches where indicated on drawings and elsewhere as required to properly balance system. Dampers shall meet SMACNA "Low Pressure Duct Construction Standards", or SMACNA "High Pressure Duct Construction Standards", depending on system pressure.

**DEFLECTORS:**

Provide deflectors at all branch take-offs, and elsewhere as required. Fabricate of galvanized steel sheet of same thickness as used in ductwork of corresponding size. Securely anchor vanes to duct or casing, and brace free-standing edges as specified for turning vanes in elbows.

**ACCESS DOORS:**

Provide access doors of suitable size where required to service equipment. Fabricate doors of 24 U. S. Gauge galvanized steel hinged to a 24 gauge galvanized mounting frame, and provide with fastening devices to give tight closure on felt gasket. Doors for insulated duct shall be double panel construction with 1" rigid insulation material between metal panels.

**ACCESS PANELS:**

Construct access panels as specified for access doors, and provide at all locations where any operable device occurs inside ducts, i.e., dampers, controls, filters, louvers, fire dampers, etc.

**SPECIALTIES:**

Where drawings or specifications require that ducts be insulated, make provision for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors and similar operating devices. A metal collar equivalent in depth to insulation thickness (and of suitable size to which insulation may be finished) shall be mounted on duct. Insulation on duct shall extend continuously through walls, etc.

Provide extension collars for outlets, air guide vanes, and other specialties where they occur in the ducts.

**DUCT SILENCER:**

Provide pre-fabricated sound attenuating duct silencers where indicated on the drawings constructed of minimum 22 ga. galvanized casing metal, perforated metal inner liner with aerodynamic leading & trailing edges constructed in accordance with ASTM E84 for flame & combustion retardancy. Attenuation data

shall be provided with submittal. Pressure drop shall not exceed 0.75" w.g. Approved manufacturers are Rink Sound Control and United McGill.

**AIR DISTRIBUTION DEVICES:**

Diffusers, registers, and grilles shall be installed indicated or implied on drawings. All ceiling diffusers and grilles shall be designed to minimize ceiling and/or wall discoloration, and shall be model and finish as indicated on drawings. Air distribution manufacturer and Contractor shall be jointly responsible for and certify delivery or exhaust. (See Testing Section for duct system.)

Items scheduled on the drawings are used for design purposes. Similar units as manufactured by Nailor Industries, Titus, Krueger, Price and Metal\*Aire shall be considered equal. Maximum dba shall be 30. If indicated on the drawings, supply and return grilles shall be equipped with volume dampers of the opposed blade type. The dampers are to be adjustable from the face. All grilles, registers and diffusers shall have white baked enamel finish, unless indicated otherwise.

**DAMPERS:**

Balancing dampers shall be installed at each branch run to allow for proper balance of the system. Each damper shall be supplied with a quadrant locking device which extends beyond the ductwork for external adjustment.

**FIRE DAMPERS:** See Section 15825

**FLEXIBLE CONNECTIONS:**

For low velocity duct work (less than 2400 FPM), provide flexible connections at inlet and outlet of each fan connected to ductwork and elsewhere as indicated. Flexible connections shall be 6 inches wide, waterproof and fireproof, and shall be 24 gauge Metaledge Ventfab, as manufactured by Ventfabrics, Inc.

**DUCT SEALANT:**

Prior to insulating, all duct joints (except gasketed joints), seams and connections shall be sealed with brush-on type water-based sealant equal to United-McGill Duct Sealant. Apply in accordance to manufacturer's instructions and / or recommendations.

**CLEANING DUCT SYSTEM:**

Upon complete installation of ducts, clean entire system of rubbish, plaster, dirt, etc., before installing any outlets. After installation of outlets and connections to fans are made, blow out entire systems with all control devices wide open.

**DUCTWORK INSULATION:** See Section 15500, Mechanical Insulation

**DUCT LINER:** Removed. Not allowed on this job.

**FLEXIBLE DUCTS:**

Flexible ducts shall be not less than 3' or greater than 8' long of flexible air duct with a sum total of 90° maximum of bends. Flexible duct shall be UL 181 insulated Class 1 rated for medium pressure applications (up to 8" w.g.). Flexible duct shall be ATCO Rubber Products no UPC-018 or as manufactured Owens Corning or approved equivalent. Flexible duct shall meet all requirements of NFPA No. 90A. Duct shall be complete with 1.25" Type B factory applied insulation. Make connection to metal duct take-off with (2) nylon straps over tape.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I: GENERAL**

**SCOPE:**

Provide all plant, labor, materials, accessories, and equipment required to install the fire dampers as shown on the accompanying plans and specified in this document.

**WORK INCLUDED:**

- a. Fire & smoke dampers
- b. Fuse links
- c. Access doors

**PART II: PRODUCTS**

Furnish fire dampers as shown on the drawings as required by the North Carolina State Building Code.

**FIRE DAMPERS:**

Fire dampers shall have the following characteristics:

- a. Fire dampers shall be constructed in accordance with NFPA Bulletin No. 90A, and shall be labeled and listed by Underwriter's Laboratories for the purpose for which they are being used. They shall have fusible links, spring locks, and shall be so arranged that air flow will hold blades closed.
- b. The fire dampers shall be Type B with the opened damper out of the air stream and not restrict free area.
- c. Location and type of fire dampers are shown on the drawings.
- d. Dampers mounted horizontally shall be equipped with spring loading for closure.
- e. Fusible Link shall be rated at 165° F

Fire dampers shall be equal to those manufactured by Ruskin. Access doors shall be insulated sheet metal equal to those manufactured by Ventfabrics.

**ACCESS DOOR:**

See section 15800.

**PART III: EXECUTION**

Install fire dampers in accordance with SMACNA requirements and manufacturer's instructions.

Provide access doors for purpose of resetting fire linkages in the ductwork and, where needed, in the building walls, floors or ceilings. Lay-in ceilings do not require access doors.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I: GENERAL**

Provide all labor, materials, accessories, and equipment required to furnish and install louvers as shown on the accompanying plans and specified in this document.

**PART II: PRODUCTS**

**STATIONARY LOUVERS:**

Louvers shall have the following features:

- a. The unit shall have a rain proof exterior with a built-in backdraft damper ( for exhaust applications)
- b. The blades shall be constructed of not lighter than 14 gauge 6063T5 extruded aluminum @ 3" o.c.
- c. Frame shall be constructed of not lighter than 12 gauge extruded aluminum.
- d. Provide blade edge of vinyl or rubber to give minimum leakage shall be 1 cfm/ft<sup>2</sup> at 1/2" SP.
- e. Furnish extended sill and insect screen
- f. Finish shall be Kynar 500 with 20 year warranty or approved equal – custom color(s) selected by Architect

Louvers shall be manufactured by Ruskin, Air Balance, Vent Products, Cesco or Reliable.

Submit (3) color samples for approval by the Architect.

**PART III: EXECUTION**

Install in accordance with SMACNA requirements.

*END OF SECTION*



**GENERAL:**

Furnish and install blower coil, (BC) or fan coil (FC or FCU) with type, size, and capacity as indicated on plans. Protect coil from construction dust and debris before project closeout with temporary disposable filters at unit and at return grille.

BC's and FC's shall be completely factory assembled including water coil, condensate drain pan, fan motor, filters and controls in an insulated casing in a vertical configuration. Units shall be rated and tested in accordance with ARI standard 210. Units shall be UL listed and labeled in accordance with UL 1995 for indoor blower coil units.

Vertical fan coil units shall have ducted side return air entry option as detailed on the drawings. Filters shall be accessible from side coil access panels. Provide 1 year supply of air filters as specified.

**CABINET/BLOWER:**

Unit casing shall be constructed of zinc coated, heavy gauge galvanized steel. Exterior surfaces shall be cleaned, and phosphatized, painted finish is optional. Casing is completely insulated with fire-retardant, permanent, odorless glass fiber material. Knockouts shall be provided for unit electrical power, water and/or refrigerant piping connections. Captive screws shall be standard on all access panels. Provide mounting subbase for vertical floor mount configurations. Subbase shall be constructed of heavy gauge, zinc coated galvanized steel with finish to match air handler unit.

Evaporator fan shall be a double inlet, double width, forward curved, centrifugal-type fan(s) with direct drive shall be standard. Thermal overload protection shall be standard on motor. Fan and motor bearings shall be permanently lubricated. Motor efficiency shall comply with NCSBC Volume X Energy Code.

**WATER COILS:**

Water coils shall be specifically designed and circuited for application. Provide 2-row heating coil and four or six row chilled water coil to meet design loads. Finned coil surface shall consist of aluminum plate fins securely bonded to seamless copper tubing. Coils shall be designed to allow drainage, designed for 150 psig working pressure, and tested at 350 psig.

Unit Drain pan shall be of corrosive resistant construction and have positive slope toward the drain. Provide and install a secondary overflow drain pan for each unit that is installed above a ceiling or on a mechanical platform. Install a float switch that will shut down the air handler and close the chilled water control valve upon activation. See control diagram and sequence of operation.

**MANUFACTURER:**

Units manufactured by Envirotec, Daikin, Carrier, Kreuger and ITC are acceptable provided all specifications are met or exceeded. (Trane Vertical Blower Coil Units 5 tons and Under are NOT acceptable)

VIBRATION ISOLATION:

Provide all equipment with vibration isolation bases equal to Vibration Mounting and Controls, Inc. (VMC), and shall be installed in strict accordance with manufacturer's instructions. Provide neoprene-in-shear mounts, VMC no. R-2 or approved equal, rated for load. Arrangement shall be in accordance with applicable details on drawings.

WARRANTY:

Provide unit with 5-year parts warranty and 2-year factory labor warranty.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SCOPE OF WORK:**

Furnish and install centrifugal exhaust fans, as specified herein, of sizes and capacities scheduled and in locations shown on drawings.

**GENERAL:**

Wall and roof exhaust fans shall be of the centrifugal, direct-drive type unless noted otherwise on plans. Construction of the fan housing shall be of heavy gauge aluminum. All spun parts shall have a rolled bead for added rigidity and shall be specially spun so as to seal the pores of the aluminum providing greater resistance against oxidation and deterioration.

The fan wheel shall be all-aluminum of the centrifugal blower type featuring backward inclined blades and a tapered inlet shroud. Wheels shall be statically and dynamically balanced. Inlet cone shall be aluminum and of the centrifugal blower type. Motor and drives shall be enclosed in weather-tight compartment, separate from the exhaust air stream. Air for cooling the motor shall be supplied to the motor compartment by way of an air passage, from an area free of contaminated exhaust fumes. Motor shall be of the heavy duty, permanently lubricated, sealed ball bearing type.

The entire drive assembly and wheel shall be removable, as a complete unit from the support structure without disassembling the external fan housing. The complete drive assembly shall be mounted on rubber vibration isolation. Units shall be of Type B construction and shall carry a one year warranty. Fans shall be licensed to bear the AMCA ratings seal for air sound performance.

Acceptable manufacturers are Greenheck, Penn, Cook, Carnes, and Acme.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**GENERAL:**

Furnish and install 1 year supply of 1" air filters disposable air filters in all fan coils and 2" for air handlers. One year supply consists of four (4) sets for 60 day replacement cycle and does not include first sets installed during start-up and replacement prior to Owner acceptance of building.

Provide an air filter replacement schedule indicating size and quantity for each HVAC unit with submittal for approval.

Air filters shall be medium efficiency, pleated, disposable type. Each filter shall consist of cotton and synthetic media, media support grid, and enclosing frame. The filter shall be listed and identified on the frame as Underwriters' Laboratories Class 2.

Filter shall have not less than 2.3 square feet of media per square foot of filter face area and not less than 16 pleats per linear foot of filter face area. A 96% open area media support grid of welded wire construction, coated with rust inhibitor shall be bonded to the air exiting side of the filter. The enclosing frame shall be of high wet-strength beverage board with diagonal support members bonded to the air entering and air exiting side of each pleat. The inside periphery of the enclosing frame shall be bonded to the filter pack.

Filter shall have an average efficiency of 25-30%, and an average arrestance of not less than 90% in accordance with ASHRAE Standard 52.1-1992. The minimum MERV when tested under ASHRAE 52.2 shall be no less than MERV 9. Initial resistance at 375 feet per minute approach velocity shall not exceed 0.28" iwc

A test report corresponding to each of the aforementioned ASHRAE Standards are required submittals.

**MANUFACTURER:**

Filters shall be Farr 30/30 Dual 9.

Units manufactured by Flanders and American Air Filter are acceptable provided all specifications are met or exceeded.

*END OF SECTION*

## 15900 BUILDING AUTOMATION SYSTEMS

### **PART 1 - GENERAL**

#### 1.1. APPLICABLE SECTIONS

- A. 15900 BAS Sensors and Devices

#### 1.2. RELATED DOCUMENTS

- A. The Contract Drawings are directly applicable to this Section, and this Section is directly applicable to them.
- B. The general provisions of the Contract, including General and Supplementary Conditions and/or Division 01 Specification Sections, are directly applicable to this Section, and this Section is directly applicable to them.
- C. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
- D. Collectively, these items will be referred to as the Contract Documents.

#### 1.3. DEFINITIONS AND ABBREVIATIONS

- A. Where definitions in Division 01 conflict with the definitions herein, Contractor will comply with the most stringent requirement.
- B. BAS Component: a generic reference to any hardware component which is provided by Contractor, including but not limited to controllers, power supplies, transformers, relays, actuators, sensors, or other devices.
- C. Building Automation System (BAS): Also referred to as Building Management System (BMS), Direct Digital Control (DDC).
- D. Building Controller: Controller, which is at, and controlling at, the building-level. Could also be a large portion of a building, such as a wing, depending on hardware capability. Generally, are the middle tier of the overall BAS network, and report up to a Building or Enterprise Supervisor. Also, generally what Device Controllers would be integrated with. See Section 2.5 System Architecture for full definition and specification.
- E. Building-Level Network (BLN): An ethernet, fiber, and/or wireless network dedicated to the BAS, which connects Building Controllers and Building Supervisors. The BLN may be a separate network from Owner's LAN, or as part of the LAN, which has been segmented to be used exclusively by the BAS. See Section 2.5 System Architecture for full definition and specification.
- F. Building Supervisor: Server, which is at, and controlling at, the building-level. Generally used when Building Controllers do not have sufficient hardware capability to support an entire building. Generally, are the middle tier of the overall BAS network, and installed on a Server in lieu of being a stand-alone piece of hardware. Also, generally what Building Controllers would be integrated with. Building Supervisors may be further integrated to an Enterprise Supervisor. See Section 2.5 System Architecture for full definition and specification.
- G. Controller: A generic reference to a BAS Controller, including but not limited to Device Controllers and Building Controllers.
- H. Contract Documents: All documents which compose the project, including but not limited to drawings, specifications, RFPs, scope of work, general conditions, and supplemental conditions.
- I. Control Panels: an assembly composed of an enclosure and one or more BAS Component(s).
- J. Critical: A special area or zone which receives specialized BAS Components.

- K. Device Controller: Also referred to as Field-Level Controller. Controller, which is at, and controlling at, at the device-level. Device in this instance is understood to reference MEP Equipment. Generally, are the lowest tier of the overall BAS network, and report up to a Building Controller. See Section 2.5 System Architecture for full definition and specification.
- L. Device-Level Network (DLN): A copper, ethernet, fiber, and/or wireless network dedicated to the BAS, which connects Device Controllers and Building Controllers. See Section 2.5 System Architecture for full definition and specification.
- M. Enterprise Supervisor: Server, which is at, and controlling at, the enterprise-level. Generally, are the highest tier of the overall BAS network, and installed on a server in lieu of being a stand-alone piece of hardware. Also, generally what Building Controllers and/or Supervisors would be integrated with. See Section 2.5 System Architecture for full definition and specification.
- N. Field-Level: See Device Controllers and Device-Level Network.
- O. Furnish: To supply and deliver to project site, ready for installation.
- P. Install: To place in position for service or use.
- Q. Local Area Network (LAN): Ethernet, fiber, and/or wireless network which connects computers and other networkable devices (printers, etc.), and has a connection to the WAN. See Section 2.5 System Architecture for full definition and specification.
- R. Manufacturer: The brand of the BAS being provided (ex: Distech, Honeywell, etc).
- S. MEP: Mechanical, electrical, and plumbing.
- T. MEP Equipment: Where MEP Equipment is used, it is understood to mean any piece of MEP Equipment which the BAS will in some way, shape, or form, interface with, via hardwired connection or integration. MEP Equipment includes, but is not limited to VAV, AHU, RTU, split systems, hot water heaters, heat exchangers, boilers, chillers, and pumps.
- U. MSI: Master Systems Integrator: see MSI section for full definition and specification.
- V. Owner: The financial provider and user of the BAS, as well as Owner Representatives.
- W. Owner Representatives: Representatives for the Owner which are on staff, contracted, or hired to protect the interests of the Owner, such as Engineers, Architects, Commissioning Agents, and other parties.
- X. Project: The facility/building as defined in the Contract Documents.
- Y. Server: A computer in which BAS software is installed on.
- Z. Sequence of Operation: The steps that MEP Equipment takes to achieve the desired operation to provide optimal comfort and/or ventilation for the Project.
- AA. Substantial Completion: Written authorization by the Owner that the project has reached a point of completion that it can be utilized.
- BB. Supervisor: A generic reference to a BAS Supervisor, including but not limited to Building Supervisors and Enterprise Supervisors.
- CC. Provide: To furnish and install, complete and ready for intended use.
- DD. Vendor: The installer, integrator, and/or contractor for the BAS being provided.
- EE. Wide Area Network (WAN): Ethernet and/or fiber-based network which connects multiple facilities via the internet. See Section 2.5 System Architecture for full definition and specification.
- FF. Warranty Period: The time between Substantial Completion and the duration of Warranty, as specified.

#### 1.4. GENERAL SPECIFICATIONS

- A. Contractor shall provide all hardware, software, configuration, programming, graphics (GUI), checkout, alarms, trending, functional testing, and commissioning necessary to provide a complete and fully functioning BAS. Contractor shall include all hardware, control wiring, wiring accessories, wiring connections, software, and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system, now and in the future.
  - 1. Provide all necessary BAS Components on each piece of MEP Equipment to:
    - a. Perform the specified Sequence of Operation and meet the design/performance intent of the MEP Equipment.
    - b. Comply with BAS Components as shown on the control diagrams.
    - c. Comply with the point lists.
    - d. Comply with the Specifications herein.
    - e. Comply with the design intent of the BAS.
  - 2. Where the Sequence of Operation, control diagrams, points list, or specifications conflict with each other, Contractor will comply with the most stringent requirement.
- B. It is Contractor's responsibility to review all the Contract Documents and report any discrepancies to Owner.
- C. Substitutions
  - 1. Wherever the words "approved equal," "for review," or "for acceptance" are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of BAS Component for that specified, submit all information pertinent to the adequacy and adaptability of the proposed BAS Component to Owner and secure their approval before the BAS Component is ordered.
- D. Warranty
  - 1. Warranty period shall be for 24 months after project construction closeout and owner's receipt of the Certificate of Occupancy. The entire BAS and all ancillary equipment required for its operation shall be free from defects in workmanship and material under normal use and service. If within the twenty-four months from the date of acceptance/occupancy the installed equipment is found to be defective in operation, workmanship or materials, Contractor shall replace, repair, or adjust the defect at no cost to Owner.
  - 2. Corrective software and/or hardware modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.
    - a. Modifications made which are corrective to one piece of MEP Equipment will be replicated to all MEP Equipment for consistency in programming.
    - b. User documentation will be updated in all locations, including but not limited to hard copies, Control Panel hard copies, O&Ms, and PDF copies accessible via download inside the BAS system.
    - c. Maintain revision control (i.e., v1\_05) to indicate which is the latest version of all documentation, software, and programming.
  - 3. Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any changes made by Owner unless Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

4. At no cost to Owner, during the Warranty Period, Contractor shall provide maintenance services for software including all current software updates, firmware, and hardware. Prior to the closeout of the warranty period, Contractor shall meet with Owner to address any questions or concerns and offer ongoing services to Owner.
  5. Electronic Actuators: Parts and labor for 5 years from the date of substantial completion.
  6. Air and Water Flow Meters: Parts and labor for 3 years from the date of substantial completion.
- E. Extended Warranty
1. Contractor shall include a 3 year (36 Month) Extended Warranty agreement to oversee maintenance, adjustments and owner support for the controls system after expiration of the 24 month Basic Warranty period. This agreement shall include remote support for minor hardware, software or owner issues. Agreement shall also include additional on-site time to address major Control System (Hardware or Software) issues that have one or more pieces of equipment off-line. Contractor shall be on-site to address the major issue within 36 hours on normal work days or the following Monday if 36 hour time limit falls after regular business hours on Friday afternoon or over the weekend.
- F. Training
1. Provide eight hours of training for Owner personnel, and/or maintenance contractor, on the operation and maintenance of the BAS. Owner may wish to video tape the training session.

#### 1.5. CODES AND REFERENCE STANDARDS

- A. Comply with all current federal, state, and local codes, requirements, ordinances, and regulations, in accordance with the authority(ies) having jurisdiction (AHJ).
- B. Comply with the National Electric Code (NEC).
- C. Comply with all manufacturer guidelines and requirements.
- D. Comply with all Owner rules, guidelines, procedures and requirements, including Owner IT.
- E. The latest published edition of a reference shall be applicable to the Project unless identified by a specific edition date.
- F. All materials, installation, and workmanship shall comply with the applicable requirements and standards addressed within the following references:
  1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
  2. American National Standards Institute (ANSI)
  3. UL 916: Energy Management Systems
  4. LonMark International
  5. BACnet Testing Lab

#### 1.6. COORDINATION OF WORK AND INTEGRATION

- A. Certain LonMark, BACnet, Modbus, and other products, systems, and interface devices, may be provided by other trades via MEP Equipment. Examine the Contract Documents to ascertain the requirements to install, wire, program, commission, and/or interface to these systems. Particular attention must be paid towards the interface boards submitted by the various MEP Equipment providers. It is this Contractor's responsibility to verify the submitted interfaces will integrate properly into the BAS. Report any discrepancies to Owner. Discrepancies brought to Owner's attention after the procurement of that piece of MEP Equipment will be integrated at no additional cost to Owner. Contractor will provide additional interface(s) needed to integrate piece of MEP Equipment.
- B. Controls contractor is responsible for reviewing the equipment submittals for ALL equipment to be integrated into the BAS system prior to equipment being ordered to verify proper power



voltages, control voltages, control signals, control points, etc. for proper seamless integration and control of the equipment provided by the other contractor.

- C. Contractor shall review MEP Equipment for compliance with control diagrams, Sequence of Operation, and points lists. Report any discrepancies to Owner.
- D. Wherever work interconnects with work of other trades, coordinate with other trades and with Owner to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.
- E. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Owner and/or General Contractor prior to installation.
- F. Coordinate sources of 120V power with the Electrical Contractor and Owner. Extend power from source(s) as needed.
- G. Coordinate location of data ports/drops to the LAN/WAN with the Electrical Contractor and Owner.
- H. Coordinate shipping of BAS Components to another Contractor or manufacturer for factory-installation.

#### 1.7. SPARE PARTS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide one replacement for each unique actuator, Controller, thermostat, wall module, or any other BAS Component provided.

#### 1.8. QUALITY ASSURANCE

- A. The BAS and BAS Components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- B. Control Panels, both new and modified, shall comply with UL 508A.
- C. Electrical Components, Devices, and Accessories: UL listed and labeled as defined in NFPA 70.

#### 1.9. CONTRACTOR QUALIFICATIONS

- A. Qualifications may be requested from Contractor prior to the bidding process. Owner reserves the right to not allow Contractors to bid if they do not meet the qualifications or provide them in a timely manner. Qualifications will be provided for all items below in an orderly format for review by Owner.
- B. Contractor shall have a successful history in the design and installation of the BAS being provided that consists of web-browser monitoring and control of LonWorks, BACnet, and/or Modbus Device Controllers. These projects must be on-line and functional such that Owner can observe the BAS in full operation. Include proper references, contact names, emails, and phone numbers of these reference projects, with a minimum of five projects similar to this Project.
- C. Contractor shall demonstrate experience in BAS installations for not less than five years, in BAS installation projects with point counts equal to this Project, and systems of the same character as this Project.
- D. Contractor shall have specialized in and be experienced with the installation of the proposed product line for not less than five years, on at least ten projects of similar size and complexity.
- E. Contractor shall be factory authorized by manufacturer of product line and be in good standing with the manufacturer.
- F. Contractor shall be located within 50 miles of Project.
- G. Contractor shall be a Certified Tridium Systems Integrator.

- H. Contractor shall have a minimum of three, Niagara Technical Certification Program (TCP) certified personnel.
- I. Contractor shall have a minimum of three personnel who are certified in LonWorks, BACnet, and/or Modbus line(s) of controls to be installed as part of this project.
- J. Be of sufficient size to provide service, including both routine maintenance and emergency support within 24 hours upon receipt of request.

#### 1.10. ACTION SUBMITTALS

##### A. Product Data Submittal

1. Submit manufacturer's technical product data for each BAS Component, including but not limited to Controller, sensor, actuator, relay and panel, indicating dimensions, capacities, performance, electrical characteristics, and material finishes. Also include installation and start-up instructions.
  - a. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate, mark-through, and highlight only applicable information.
  - b. Generic submittals will be automatically rejected.
2. Submit documentation indicating LonMark, NICs, and/or BTL compliance and include Protocol Implementation Conformance (PIC) Statements.

##### B. Shop Drawings Submittal

1. Submit shop drawings. Shop drawings will include:
2. Bill of Materials (BOM): indicating equipment served, quantity, manufacturer, point range (i.e. 0-10 in. w.c.), sensor range (i.e. 0-10V), and model number for all BAS Components being provided.
  - a. Disconnect Schedule: additionally, indicating MCA, MOP, voltage, # of phases, size, NEMA rating, # of poles, and neutral (Y/N).
  - b. Starter Schedule: additionally, indicating horsepower, voltage, # of phases, size, NEMA rating, and bypass.
  - c. VFD Schedule: additionally, indicating horsepower, voltage, # of phases, size and NEMA rating, bypass (Y/N), number of contactors (if bypass), disconnect (Y/N), and disconnect type (fused/non-fused).
  - d. Hydronic Valves (Pressure-Dependent): additionally, indicating gpm, line size, calculated Cv and design pressure drop, actual Cv and actual pressure drop, close-off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing/diverting (if 3 way), service (2-position/modulating), and fail position.
    - A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
    - B) Actuator will be scheduled with the valve per the standard BOM.
  - e. Hydronic Valves (Pressure-Independent): additionally, indicating gpm, line size, selected valve gpm, maximum valve gpm, min/max pressure drops, close-off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing/diverting (if 3 way), service (2-position/modulating), and fail position.
    - A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
    - B) Actuator will be scheduled with the valve per the standard BOM.
  - f. Steam Valves: additionally, indicating lb/hr, inlet pressure, outlet pressure, line size, calculated Cv and design pressure drop, actual Cv and actual pressure drop, close-

- off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing or diverting (if 3 way), service (2-position/modulating), and fail position.
- A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
  - B) Provide sizing methodology/calculations for manufacturer selected.
  - C) Actuator will be scheduled with the valve per the standard BOM.
- g. Air Flow Metering Stations (AMFS): additionally, indicating duct size, output, network capable (LonWorks/BACnet), and number of probes/sensors.
  - h. Water/Steam Flow Meters: additionally, indicating line size, output, network capable (LonWorks/BACnet), and flow meter style/type.
  - i. Damper Schedule: additionally indicating, duct size, blade type, leakage, and construction.
  - j. VAV schedule: indicating VAV type, K factor, and max/min/reheat flows.
3. Schematic Flow Diagram: schematic representation of MEP Equipment. Diagram will show all BAS Components on schematic, point name, and point number (i.e. UI-1). Where MEP Equipment varies slightly, schematic will be clearly diagramed to indicate any differences between each piece of MEP Equipment. Stating the schematic as "typical" is not acceptable.
  4. Wiring Diagram: indicating power, signal, and control wiring. Where terminal blocks are provided, provide indication where wiring terminates to terminal block.
  5. Sequence of Operation: Any modifications proposed to the Sequence of Operation will be clearly marked up as part of the shop drawings or submitted as an annotated Microsoft Word document in addition to the shop drawings. A default Contractor Sequence of Operation, included without regard to the Contract Document's Sequence of Operation, will result in a rejected submittal.
  6. Control Panel Diagrams: indicating panel faces, with layouts of any BAS Components to be installed in the panel face, BAS Component locations inside panel, and labeling of BAS Components.
  7. One-line diagram for all controllers showing the network layout. Where Project is to connect with an existing BAS, indicate how the new network will integrate with the new and/or existing BAS Components.
  8. Indicate anticipated device ID, Network number, MAC Addressing, and Max Masters for all BACnet devices. Provide logical schema for BACnet addressing.
  9. Individual floor plans with device (controllers, routers, sensors, etc.) locations with all interconnecting wiring routing including space sensors, Device and Building-Level Network wiring, power wiring, and low voltage power wiring.
  10. Additional Requirements:
    - a. Point names will be consistent between the schematics and wiring diagrams.
    - b. Misc. Points List: where controllers being provided for other purposes are also used to control a miscellaneous point, such as an exhaust fan or lighting contactor, provide a list of those miscellaneous points in a concise format for quick identification of their location and associated Controller.
    - c. Provide a complete list of any deviations of submitted products to the specification in this document.
    - d. Where existing BAS Components are being reused, such as controllers or sensors, clearly indicate (via coloring, line type, etc) the BAS Components being reused as "existing" and new components as "new."

C. Graphics Submittal

1. Provide screen captures of graphical user interfaces developed by Contractor on previous projects. These screen shots shall represent actual work performed by Contractor and not generic work from the line of controls which Contractor represents. Screenshots will be applicable to the MEP systems as part of this project. "Generic" screenshots of MEP systems will not be accepted. Provide client contact information for Owner to validate. Any comments from the submittal process will be incorporated into the actual graphics for the project.
2. Follow Owner's graphics standards.
3. Zoning Map
  - a. Provide submittal of graphic floorplans for markup by Owner to identify required zoning to use for scheduling. Floorplan markup will be used by Contractor to segment equipment that satisfies the identified zones.

D. Point-Naming Submittal

1. Points shall be named consistently. Provide list of point names and point conventions.
2. Point naming shall be consistent with an existing standard, such as Project Haystack.

E. IP Drop Request Submittal

1. Provide list of BAS Component(s) which need an IP drop to the LAN/WAN.
2. Provide location, quantity (if multiple per Control Panel/location), and IP address requirements (DHCP, fixed, etc), and total number of IP address reservations, including room for future growth.
3. Provide list to a minimum of ten business days' notice prior to needing the drop.

F. Schedule/Sequence of Construction Submittal

1. Provide schedule and sequence of construction, as it pertains to the installation of the BAS, for review.

G. Functional Performance Testing (FPT) Submittal

1. Provide FPT agendas and testing procedures for review.
2. FPT should include at a minimum Sequence of Operation, point-to-point verification to graphical interface, historical data logging, and alarms testing procedures.

1.11. START-UP AND ASSOCIATED TESTING SUBMITTALS

A. Point-to-Point Testing/Checkout Sheets Submittal

1. Prior to startup of MEP Equipment, Contractor will provide checkout sheets for each piece of MEP Equipment.
2. Checkout sheets will contain at a minimum:
  - a. Equipment name and location.
  - b. Associated Controller address (MAC or Node ID), name, type, and instance number.
  - c. Point name, type (resistance, amperage, voltage, etc), and range (i.e., -5 to +5 in w.g.).

B. Start-Up Testing Submittal

1. As part of the startup of MEP Equipment, Contractor will provide start-up testing sheets for each piece of MEP Equipment.
2. Start-up testing sheets will contain at a minimum:
  - a. Equipment name and location.
  - b. Sequence of Operation and step-by-step procedure used to check programming and configuration.

- c. Any modifications required to Sequence of Operation for MEP Equipment performance.
  - d. Final graphical screens.
  - e. PID tuning parameters for each loop.
- C. Adjusting and Calibration Submittal
- 1. As part of the startup of MEP Equipment, Contractor will provide a calibration submittal for each piece of MEP Equipment.
  - 2. Calibration submittal will contain at a minimum:
    - a. Equipment name and location.
    - b. Point name, type, and range.
    - c. Sensor type and manufacturer's stated accuracy.
    - d. Calibration type (single point, two point, etc).
    - e. Checking, adjusting, and calibration data.
    - f. Sensor installed accuracy.
    - g. Sensor pass, fail, replaced, etc.
    - h. Calibration equipment used and associated certificates of calibration, including expiration dates.

#### 1.12. CLOSE-OUT SUBMITTALS

- A. Operating and Maintenance Manuals
- 1. Provide all documentation as required in the submittal processes to-date, updated to as-built conditions.
  - 2. In addition, provide the following:
    - a. Include control response, settings, set points, throttling ranges, gains, reset schedules, adjustable parameters, and limits.
    - b. A table (or similar) of all Testing, Adjusting and Balancing (TAB) values for each piece of MEP Equipment and BAS-calibrated equipment, such as airflow metering stations (AFMS).
    - c. Any O&Ms for equipment not originally included in the submittal, in addition to product data.
    - d. Accurately record actual set points, calibrations/offsets, and settings of controls, final Sequence of Operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.
    - e. Database of all point names.
- B. As-Built Shop Drawings
- 1. Provide PDF of shop drawings which have been corrected to reflect the as-built state.
    - a. Incorporate any redlines made in field during installation.
    - b. Update Sequence of Operation to reflect MEP Equipment operation as changed during installation, commissioning, and/or functional performance testing.
    - c. Provide reference to being "as-built" version on each sheet of the shop drawings.
  - 2. Provide hard copy of appropriate shop drawing page(s) inside each Control Panel.
- C. Software Closeout
- 1. Provide all usernames, passwords, software, GUI, databases, licenses, and application programming tool(s) to Owner.

2. Provide software backup of entire BAS and associated components on digital media for Owner record. Coordinate file location of automatic backup of software with Owner.

D. Reference 3.11 Closeout for additional requirements.

#### 1.13. MATERIALS AND EQUIPMENT

- A. All materials shall meet or exceed all applicable referenced standards, federal, state, and local requirements, referenced standards, and conform to codes and ordinances of the AHJ.
- B. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where Contract Documents specifically allow existing materials to remain in place.
- C. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

#### 1.14. COLORS AND LABELING

- A. Where requirements in 15190 conflict with the requirements below, Contractor will comply with the most stringent requirement.
- B. Provide BAS Components consistent with the following color requirements.
  1. Control Panels Blue
  2. Conduit Blue
  3. Input/Output Wiring Yellow
  4. BACnet Copper Wiring Orange
  5. LonWorks Copper Wiring Purple
  6. Modbus Copper Wiring Blue
  7. Ethernet/Fiber Cable Consistent with color of primary communication protocol.
  8. Tubing Black with White Stripe
- C. Provided BAS Components with the following labeling requirements.
  1. Controllers
    - a. Vinyl or nylon label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with MEP Equipment served by Controller, permanently mounted.
  2. Control Panels
    - a. Two-layer engraved phenolic or engraver's plastic tag, 1 inch or greater in height, adhesive backed, engraved with MEP Equipment served by panel, permanently mounted.
  3. Input/Output Wiring
    - a. Nylon or self-laminated wire-wrap label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with BAS Component connected to cable and cable number, permanently mounted at termination to terminal block in Control Panel on cable jacket.
    - b. Premade labels or wire marker tape is not allowed.
  4. BAS Component
    - a. Vinyl or nylon label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with MEP Equipment served and BAS Component purpose (ex. AHU-1 SF Start/Stop), permanently mounted.

## **PART 2 - PRODUCTS**

### **2.1. MANUFACTURERS AND VENDORS**

- A. Subject to the Specifications and requirements herein, the BAS will be provided by (listed in alphabetical order):

#### **NEW CONSTRUCTION**

1. Reliable Controls
  2. ABB Controls
  3. Distech
  4. Lynxspring
  5. Trane Tridium Compatible SC+
  6. Schneider Electric TAC I/A Series
- B. Products by the manufacturer listed shall be used for Device and Building Controllers. Sensors, actuators, valves, dampers, and other BAS Components may be manufactured by others as indicated.

### **2.2. GENERAL**

- A. Owner shall receive ownership of all job-specific configuration documentation, data files, software and/or code developed for the Project. This shall include all custom, job-specific software code, databases, and documentation for all configuration and programming that is generated for the Project and/or configured for use with the Device and Building Controllers or Building and Enterprise Supervisors, and any related LAN, WAN, Intranet, and Internet connected routers and devices.
- B. Any and all required IDs and passwords for admin and programming-level access to any BAS Component or software program shall be provided to Owner.
- C. It is Owner's intent to purchase an open system capable of being serviced and expanded by any acceptable system integrator that has and maintains certification to work on Niagara Framework systems. The Niagara Compatibility Statement (NICS) for all Niagara Software shall allow open access and be set as follows: `accept.station.in=""` `accept.station.out=""` `accept.wb.out=""` `accept.wb.in=""`. In any case, Owner shall maintain the right to direct Contractor to modify any software license, regardless of supplier, as desired by Owner.
- D. Contractor shall not install any "brand-specific" software, proprietary JAR files, applications, or utilities on Niagara Framework based devices, unless otherwise permitted. Provide exceptions to Owner for review.
- E. All Device and Building Controllers installed for the project shall not be limited in their ability to communicate with a specific brand/Manufacturer or Vendor of the BAS. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed in replacement of, or in parallel with, existing components.
- F. Device and Building Controllers shall have the ability to perform energy management routines via preprogrammed function blocks or template programs.
- G. Browser-based access: A remote/local user using a standard browser will be able access all BAS facilities and graphics via the LAN or direct connection, with proper username and password. Only HTML5 browser-based graphical user interfaces (GUI) is acceptable. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer, Edge, Firefox, or Chrome.
1. Graphics shall be Niagara "virtuals" which allow graphics to be present on both the JACE and Supervisor, allowing for an update in one location to be automatically applied to the other.

- H. Remote data access: The system shall support browser-based remote access over the Internet to the building data.
  - 1. The Contractor shall coordinate with Owner IT to ensure all remote browser access is protected with the latest BAS software updates.
  - 2. The Contractor shall coordinate with Owner IT to ensure a VPN (Virtual Private Network) is installed to protect Owner from cyber-attacks.
- I. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a Supervisor server on the LAN. User tools for BLN and/or DLN management shall be provided and licensed to Owner and shall allow unrestricted configuring, updating, maintaining, and expanding of all current devices, configurations and settings.
- J. Database Schema shall be published and provided to Owner to facilitate easy access to BLN and DLN data.
- K. Owner shall be the named license holder of all software associated with any and all incremental work on the project. Contractor will coordinate with Owner IT for any requirements regarding software/hardware licensing.
- L. Where multiple pieces of Niagara equipment exist, use single-JACE sign-on. Coordinate with Owner on requirements.

### 2.3. DEVICE COUNT AND SOFTWARE MAINTENANCE AGREEMENTS

- A. All Device Controllers, Building Controllers, and Supervisors which have a license structure to where only a certain quantity of BAS Components or devices can connect to it shall be selected such that there is a minimum 25% capacity for future BAS Component or device connections. (i.e. if there are 80 connected devices, the license shall allow for  $80 \times 1.25 = 100$  potential device connections (20 extra device connections possible).
- B. All Building Controllers and Supervisors which have a license structure requiring a Software Maintenance Agreement (SMA) shall be for a period of five years.

### 2.4. SYSTEM PERFORMANCE

- A. Description: The BAS shall comply with the following minimum performance requirements. Performance requirements are based on a fully functioning BAS with all trends and alarms enabled:
  - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
  - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
  - 3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
  - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
  - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

### 2.5. SYSTEM ARCHITECTURE

- A. The system architecture provided shall incorporate hardware and software resources sufficient to meet the functional requirements of these Specifications. The Building and Device-Level Network shall be based on industry standard open platforms as specified herein, and utilize commonly available operation, management, and application software. All software packages and databases shall be licensed to Owner to allow unrestricted maintenance and operation of the BAS. Contractor shall include all items not specifically



itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.

- B. Reference 4.1 Network Diagram for diagram of System Architecture layout.
- C. The system architecture shall consist of a Wide Area Network (WAN), a Local Area Network (LAN), a Building-Level Network (BLN), and one or more Device-Level Network(s) (DLN), as well as an Enterprise Supervisor, a Building Supervisor, Building Controller(s), and Device Controller(s), as applicable.
  - 1. Wide Area Network (WAN): WAN infrastructure provided by Owner. Contractor will coordinate with Owner IT for configuration (ports, firewall, etc) for a successful BAS installation.
    - a. The WAN infrastructure shall be used to connect the Enterprise Supervisor to the Building Supervisor and/or Building Controller(s).
  - 2. Local Area Network (LAN): LAN infrastructure provided by Owner. Contractor will coordinate with Owner IT for configuration (ports, firewall, etc) for a successful BAS installation.
    - a. The LAN infrastructure shall be the connection point to the WAN for the BAS, and also serve as the BLN.
  - 3. Building-Level Network (BLN): BLN shall be a segmented network on the Owner's LAN.
    - a. The BLN shall be used for connection of Building Controller(s) and/or Building Supervisor only. No Device Controller(s) shall be connected to the BLN.
  - 4. Device Level Network (DLN): DLN infrastructure provided by Contractor.
    - a. DLN will be BACnet TCP/IP (Ethernet).
    - b. Contractor will provide one or more DLNs to maintain network speeds as specified herein.
    - c. Additional DLNs of a different protocol than listed may be added to integrate unique pieces of equipment not provided by Contractor, however all Contractor-provided equipment shall be consistent with the DLN above.
  - 5. The LAN will be under construction and not necessarily complete prior to work commencing. As such, a temporary BLN will be provided by Contractor for functionality of the BAS. This may include wireless access points, switches, or other temporary hardware for full functionality. Upon completion of the LAN, which will also serve as the BLN, Contractor shall remove the temporary equipment and provide final installation of devices to the permanent BLN. Testing of the system will be provided to ensure functionality is the same as on the temporary system.
  - 6. The LAN is existing and segmented for the BLN.

#### 2.6. SYSTEM ARCHITECTURE, ADDITIONAL REQUIREMENTS

- A. Niagara Framework will be Niagara 4 (N4), with the latest stable released installed (as identified by Contractor) and will be compatible with any existing Niagara systems. Where the incorrect software version is installed, it shall be corrected at no additional cost to Owner.
- B. Prior to bid, where a modification to the System Architecture is desired, Contractor will obtain permission for the proposed System Architecture. Contractor will provide documentation with proposed modifications and how they will improve the System Architecture as specified. If not approved, Contractor will provide the System Architecture as specified.
- C. Prior to the bid, Contractor may request for additional connections to the WAN/LAN beyond the ones specified herein. Should those connections be disallowed, Contractor shall provide additional BLN(s) or DLN(s) at no additional cost to Owner.

- D. Capacity of any BLN or DLN shall be limited to 70% of the allowable device count to allow for future minor modifications or expansions to the network. Provide calculations on request.
- E. Device Controllers shall communicate on a hardwired network.
- F. Twisted-Pair Based Device Level and/or Building Level Networks (DLN/BLN):
  - 1. BACnet MS/TP networks where the baud rate for equipment is “fixed” and cannot be changed shall be segmented from the main DLN(s). The main DLN(s) will not be slowed to accept Device Controllers with slower baud rates than the majority of the Device Controllers can achieve.
  - 2. ARCnet and/or Token-Ring based DLNs shall not be acceptable.
  - 3. The communication speed between Device Controllers shall be sufficient to ensure fast system response time under any loading condition. At a minimum, network speed shall be minimally 78K bits per second (LonWorks FTT-10A), 19.2K bits per second (Modbus RTU), 76,800 baud (BACnet MS/TP).
    - a. Where speeds must be reduced, provide justification to Owner for approval.
  - 4. Provide a maximum of 40 LonWorks FTT-10A controllers per segment. Provide a maximum of 25 BACnet MS/TP controllers per segment. Provide a maximum of 25 Modbus RTU controllers per segment.
    - a. Controller counts may be increased where specifically recommended/approved by the Manufacturer and system performance will be achieved as specified. If network performance suffers due to excessive controllers, Contractor shall provide additional BLN(s) or DLN(s) at no additional cost to Owner.
- G. Ethernet Based Device Level and/or Building Level Networks (DLN/BLN):
  - 1. Where DLN is an ethernet-based network (vs traditional copper twisted-pair network), the requirements of the BLN shall also apply to the DLN.
  - 2. Ethernet-based BLN or DLN shall be consistent with Owner IT standards and requirements, and at a minimum IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000base-T gigabit Ethernet throughput. Provide all routers, switches, and other hardware for functionality.

## 2.7. DEVICE CONTROLLERS

- A. Provide a Device Controller for each piece of MEP Equipment, or as specifically identified.
- B. General
  - 1. Device Controllers shall fundamentally communicate with the protocol as specified in the System Architecture for the DLN. Device Controllers which communicate over a different protocol and then convert to the specified protocol via a protocol converter, router, or gateway are not acceptable.
  - 2. All Device Controllers shall be able to communicate peer-to-peer without the need for a Building Controller and shall be capable of assuming all responsibilities typically assumed by a Building Controller.
  - 3. Any Device Controller shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other Controller connected on the same communication cabling. So called “Slave Controllers” are not acceptable.
  - 4. A dedicated Device Controller will be provided for each piece of MEP Equipment. Controller “sharing,” where one Controller does one or more pieces of MEP Equipment, is not allowed, unless specifically approved by Owner.
  - 5. Each Device Controller shall have a minimum of 10% spare capacity for each point type for future point connection, rounded up to the nearest whole number.
  - 6. Performance

- a. Each Device Controller shall have a minimum of 64KB of RAM and 384KB of non-volatile flash memory.
  - b. Each Device Controller shall have a 32-bit microprocessor operating at a minimum of 68 MHz.
  - c. Real time clock with rechargeable battery and 20 days power backup.
7. The control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The control program shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
8. Provide single Device Controllers with the physical and software resource count for standalone operation of each piece of MEP Equipment. The Sequence of Operation and required points for control shall reside on a single Device Controller.
- a. Remote I/O modules (via a field-wired communications bus designed for remote I/O purposes) are acceptable for points required to achieve the Sequence of Operation.
    - A) BACnet, LonWorks, Modbus, and any other communication protocol designed for Device Controller to Building Controller communication is not acceptable for remote I/O communication.
    - B) Expansion I/O modules plugged directly into the Controller are acceptable for points required to achieve the Sequence of Operation.
    - C) Additional Device Controllers connected via the DLN are not acceptable for points required to achieve the Sequence of Operation.
9. Device Controllers with integral sensors or devices (i.e., a VAV terminal unit controller with integral damper actuator and pressure sensor), shall comply with the specification requirements for those sensors if they were submitted separately. If the Controller's sensors or devices do not comply, the sensors or devices will be provided separately.
10. BACnet Device Controller Specific Requirements:
- a. Each BACnet Controller on the BACnet MS/TP communications trunk shall provide a loading characteristic of 1/8th load.
  - b. Provide BACnet Controllers that are BACnet Testing Laboratory (BTL) listed (v14 or later). Controllers will be marked with the BTL certified logos. Controllers must be within the following categories:
    - A) BACnet Building Controller (B-BC)
    - B) BACnet Advanced Application Controller (B-AAC)
    - C) BACnet Application Specific Controller (B-ASC)
11. LonWorks Device Controller Specific Requirements:
- a. Provide LonWorks Device Controllers that conform to LonMark Certified Interoperability Standards. Components will be marked with the LonMark certified logos.
12. Modbus Device Controller Specific Requirements:
- a. Provide Modbus Device Controllers that conform to the Modbus Conformance Testing Program and be independently verified by an approved third-party for conformance.
- C. Configurable Device Controllers
- 1. Shall contain an application-specific control program which can be configured to meet the Sequence of Operation.
  - 2. Where a configurable Controller cannot be configured to meet the Sequence of Operation, a Programmable Controller will be used. Alternatively, Contractor may submit a

request to modify the Sequence of Operation so that a Configurable Controller may be used in lieu of a Programmable Controller.

D. Programable Device Controllers

1. Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

E. Ethernet Device Controllers

1. Provide with a 2-port or greater integrated switch.
2. Controllers should be able to be "daisy chained" to eliminate multiple dedicated ethernet drops for each Controller.

2.8. BUILDING CONTROLLERS

- A. Provide Building Controller(s) with sufficient expansions to integrate DLNs while maintaining network speed, point count requirements, spare capacity, and other requirements as specified.
- B. Building Controller(s) shall be JACE 8000 series.
  1. Provide with embedded workbench.
  2. Provide with all required expansions for LonWorks FTT-10A, RS485, etc. to achieve the necessary quantity of DLN(s).
- C. Provide sufficient quantity of Building Controllers to maintain average processing power at 70% or less. Where Building Controllers are running above 70% consistently, additional Building Controllers will be provided and DLNs rewired at no cost to the Owner.

2.9. CONTROL PANELS AND ENCLOSURES

- A. Control Panels are an assembly composed of an enclosure and one or more BAS Component(s). Control Panels will be provided for:
  1. All MEP Equipment which requires a Device Controller(s) and does not have an Enclosure for a Device Controller(s) included as part of the MEP Equipment.
  2. All Building Controller(s).
- B. Reference 1.9 Quality Assurance for Control Panel rating requirements.
  1. All Control Panels provided for MEP Equipment shall be assembled and installed in accordance with UL508A. Field wiring to the Control Panel shall be terminated to a field wiring terminal as indicated on the required drawings provided with the Control Panel. Control Panels which are modified after UL508A listing by adding BAS Component(s) not shown on the UL508A panel drawings are 1) not allowed, or 2) require UL508A recertification from an authorized UL508A inspector. In short, 'generic' UL508A Control Panels which have power prewired but contain no BAS Component(s) as listed are not allowed.
- C. Controller(s) installed inside of MEP Equipment shall only be done so in spaces/enclosures designed for a Controller to be installed (i.e. a VAV controls enclosure). The fact a Controller fits inside the space does not constitute being designed for a Controller to be installed. Controller shall not be installed on the outside of any MEP Equipment or in a plenum, even if Controller is plenum rated.
- D. Enclosures shall have continuously welded and ground smooth seams, have doors that open 180 degrees, concealed and continuous hinge, and ground studs on door and body.
- E. Indoor/inside enclosures shall be NEMA/UL Listed Type 1. Enclosure shall be powder-coated steel, consistent with color chart herein. Outdoor/outside Enclosures shall be NEMA/UL Listed 3R or 4X. Enclosure shall be power-coated steel consistent with color chart herein or stainless steel.

- F. All enclosures will be provided with a removable backplate to which BAS Components will be fastened. No BAS Components will be fastened to the enclosure body. BAS Components, such as pilot lights and switches, displays, and operator interfaces may be mounted to the enclosure door, so long as they are designed to do so. No component will sacrifice or downgrade the NEMA rating of the enclosure.
- G. Control Panels will be sized (width, height, and depth) so that all BAS Components, including but not limited to Controllers, relays, power supplies and transformers, fit inside neatly and in an organized fashion. Provide cable tray for all wire to rest in and fasten to backplate. Cable tray shall be sufficiently sized for future expansion and/or service loop for field-wiring.
- H. Control Panels which have more than one BAS Component are required to be provided prewired to numbered terminal blocks. All BAS Components and terminal blocks will be fastened to the removable backplate and wired between the BAS Components and terminal block at Contractor's panel shop. The terminal block will serve as the demarcation point between factory/shop wiring and field wiring. At no point shall field wiring cross the terminal block and be wired directly to a factory/shop-installed BAS Component. Any BAS Component that was intended to be in the field, such as a relay, will not be installed inside the Enclosure in the field.
  - 1. Exception: Enclosures which house only one BAS Component, such as a Controller, are not required to have numbered terminal blocks, and may have field wiring terminated directly to the BAS Component.
- I. Maintain separation between Class 2 wiring and other wiring, such as power, for both field and factory connections.
- J. The design intent of the Control Panels is to have the ability to, in the future, disconnect all field wiring from the terminal blocks, remove the backplate with old control components, install new backplate with new control components and reconnect wire to the terminal blocks. Contractor will maintain design intent with their panel design and installation.
- K. Where the Specification conflicts with Control Panel requirements in Division 16, Contractor will comply with the most stringent requirement.

## 2.10. CABLE, WIRING, TUBING, AND ACCESSORIES

- A. Comply with Division 16.
- B. BAS cable for input and outputs shall comply to the color chart herein and have "BAS CABLE" (or equivalent) physically written on the cable from the cable manufacturer at regular intervals.
- C. BAS cable for LonWorks shall comply to the color chart herein and have "LONMARK" physically written on the cable from the cable manufacturer at regular intervals. BAS cable for BACnet shall comply with the color chart herein and have "BACNET" physically written on the cable from the cable manufacturer at regular intervals. BAS cable for other protocols will have the appropriate protocol written on the cable.
- D. All control wiring and tubing shall be plenum rated, no riser cable or tubing is allowed. Conform with NFPA 262 Flame Test for approved plenum use without conduit.
- E. Provide with integral ripcord.
- F. Treat cable with a lubricant to increase cable pulling productivity and efficiency and to decrease the risk of cable damage due to excessive pulling strengths. A non-staining lubricant shall be applied to coat the full length of the cable during the manufacturing process. The lubricant shall produce a low coefficient of friction on the cable jacket material that reduces pulling friction by up to 70%. The lubricant shall continue to reduce friction after it has dried; remaining as a slippery film that retains lubricity for months after use. The cable lubricant shall comply with the physical and performance requirements of Telcordia Standard,

TR-NWT-002811, and Generic Requirements for Cable Placing Lubricants. The lubricant shall not contain solvents nor have a flash point.

- G. BACnet and Modbus cable will be continuously shielded. LonWorks cable must be shielded into and out of VFDs, or any other noise-generating piece of equipment. Input/output (I/O) cable need not be shielded.
- H. Ethernet cable shall comply with the color chart herein and be consistent with Owner IT standards and requirements, and at a minimum IEEE 802.3 Category 6 cable.
- I. Tubing for air pressure sensors shall be polyethylene, approved for plenum installations, have high stress-crack resistance and be resistant to ultraviolet light.

#### 2.11. TRANSFORMERS AND DC POWER SUPPLIES

##### A. Control Transformers

- 1. Class 2, sized and rated for application. Circuit breaker overcurrent protection; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. Functional Devices TR series or approved equal.

##### B. DC Power Supplies

- 1. Class 2, sized and rated for application. Overcurrent protection with auto-reset; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. IDEC PS5R-V Series or approved equal.

#### 2.12. SURGE PROTECTION

- A. Provide any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BAS Components.
- B. All BAS Components shall be capable of handling voltage variations 10% above or below measured nominal value, with no effect on hardware, software, communications, and data storage.
- C. Provide Control Panel surge protection for:
  - 1. Building Controllers and/or their associated Control Panels
  - 2. Control Panels with 11 or more hardwired input/output points entering/exiting the panel.
  - 3. Control Panels with network routers, switches, and/or other network/interface devices.
  - 4. Location(s) required by Owner based on submitted controls architecture.
  - 5. Manufactured by Ditech DTK-120HW or approved equal.
- D. Provide surge protection for DLN and/or BLN at every point network enters or leaves the building enclosure.
  - 1. Manufactured by Ditech DTK-2MHL series or approved equal for copper twisted-pair networks.
  - 2. Manufactured by Ditech DTK-110C6A series or approved equal for ethernet networks.

#### 2.13. SOFTWARE

- A. Provide one copy of Tridium Niagara Workbench software.
- B. Provide one copy of ALL programming tools for all Device Controllers. Provide multiple versions of Software as required. Software will be fully licensed and not a "partial" or "light/lite" software version. Any functionality the Manufacturer and/or Vendor has available to them will also be provided to the Owner.
- C. Install software on Owner-chosen computer. Coordinate with Owner on processing, memory, operating system, and other computer requirements.

## **PART 3 - EXECUTION**

### **3.1. PREPARATION**

- A. Examine areas and conditions under which BAS is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner and Contractor. Report any issues to Owner and/or General Contractor.
- B. These Specifications call out certain duties of Contractor and any subcontractor(s). They are not intended as a material list of all items required by the Project.

### **3.2. INSTALLATION**

- A. Provide related items and work indicated in the Contract Documents, as specified or not specified, necessary to provide a complete and fully functioning BAS, including but not limited to:
  - 1. All incidentals, equipment, appliances, services, hoisting, scaffolding, supports, tools, supervision, labor, consumable items, fees, licenses, etc.
  - 2. All BAS Components, devices, power supplies, transformers, fittings, sensors, controllers, wiring, accessories, etc.
  - 3. All wiring, including communication network, analog points, digital points, low voltage power, line voltage power, emergency power, etc.
  - 4. All associated power and low voltage connections.
  - 5. All conduit, junction boxes, fittings, panels, enclosures, hardware, etc.
- B. Utilize licensed electricians for all electrical distribution systems.
- C. The Contract Documents show the general arrangement of the respective systems. Follow as closely as actual building construction and the work of other trades will permit.
- D. Maintain redlines of shop drawings throughout installation process. Redlines will be used to generate O&Ms, and any other closeout documentation as specified herein. Shop drawings for O&Ms which are submitted unchanged from the Action Submittal phase will be required to be as-built to actual constructed conditions at no cost to Owner.

### **3.3. PRODUCT DELIVERY, STORAGE, HANDLING, PROTECTION, AND CLEANING**

- A. All products and materials shall be new, clean, and free of defects, damage, and corrosion.
- B. Ship and store products and materials in a manner which will protect them from damage, weather, and entry of debris until final acceptance.
- C. Where BAS Components are required to be factory-mounted on MEP Equipment by others, arrange for shipping of BAS Components to MEP Equipment manufacturer.

### **3.4. SITE CLEAN-UP**

- A. At conclusion of each day's work, and at the request of Owner, clean up and remove from the site all rubbish, debris, and trash accumulated during the day as a result of work of Contractor.
- B. Marks on walls and/or ceiling tiles caused by Contractor shall be cleaned by Contractor.
- C. Ceiling tiles, drywall, carpet, paint, and all architectural finishes damaged by Contractor shall be replaced by Contractor.

### **3.5. POWER WIRING, CONTROL WIRING, AND CONTROL TUBING**

- A. Comply with Division 16.
- B. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor and/or Owner.
- C. Install all wiring and cabling in conduit.

- D. Install wire, cable, and accessories with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- E. Wire safeties and limit controls to prevent operation of MEP Equipment in any selector position (off-hand-auto).
- F. Provide sleeves and conduit for passage of wiring through structural masonry, concrete walls and floors, and elsewhere for the proper protection of the BAS. Seal as required.
- G. Splices are not permitted within the BLN or DLN communication cables. Only continuous network topologies or continuous homeruns are allowed for these networks. Splices identified, including damage to cable, will result in cable being re-pulled at no additional cost to Owner.
- H. Limit DLN and BLN cable lengths to no longer than 70% of the longest dimension published by the manufacturer of the cable or Controller, between the most remote network nodes/Controllers.
- I. Shielded wiring will have shields twisted together and taped against jacket of cable. No exposed shields will be allowed. Ground shield at one end of cable.
- J. LonWorks communication network shall transition from unshielded to shielded at device prior to VFD(s), be shielded into and out of the VFD(s), and transition back to unshielded at device after VFD(s).
- K. Power wiring, control wiring, and wiring accessories (i.e. conduit) shall be consistent with color chart herein.
- L. Power wiring, control wiring, and wiring accessories shall comply with Division 16. Where the Specification conflicts with Division 16, Contractor will comply with the most stringent requirement.
- M. Install control transformers and DC power supplies inside Control Panels. Transformers randomly installed in plenum, or connected to junction box via nipple mount, is not allowed.
- N. Install surge protection for wiring as required. Surge protection for 120V shall be installed exterior to Control Panel. Surge protection for communication network will be installed in close proximity to grounding locations and bars. Route communication network such that surge protection can be installed in accordance with manufacturer's instructions. Excessive grounding wiring runs and/or grounding to structural steel for surge protection is not permitted.
- O. Maintain all bend radius requirements with control tubing. Do not kink tubing. Do not use tees, elbows, or other fittings in tubing.
- P. I/O wiring shall be labeled in accordance with 1.15 Colors and Labeling. Wire number shall correspond to wire number shown on Closeout Documentation.
- Q. I/O cabling will be sized in accordance with the load and distance traveled. Input wiring will be minimally 22AWG. Output wiring will be minimally 18AWG.

### 3.6. NETWORK MANAGEMENT FUNCTIONAL REQUIREMENTS

- A. Contractor shall thoroughly and completely program and configure BAS Components, software, supplemental software, application programming, network communications, operator workstations, computers, printer, and network communications to permit the functional requirements of the BAS herein specified. The setup shall include as a minimum the following network management procedures:
  1. Automatic backup of the BAS database to appropriate media.
  2. Program, load, and debug all software installations, including integration of third-party applications (i.e., analytics and energy management).
  3. Network user auditing routine.



### 3.7. POINT-TO-POINT TESTING/CHECKOUT

- A. As a part of installation, provide checkout (also called point-to-point testing) of all BAS Components.
- B. Prior to start-up of any MEP Equipment, ensure all points have been properly set up, including but not limited to sensor type and range.
- C. Ensure BAS Component is accessible for maintenance.
- D. Ensure sensors and devices have been installed in the correct location in accordance with actual field conditions and modifications made to the flow diagram in the Contract Documents. Ensure sensors and devices have the proper flow direction, orientation, insertion depth, and any other applicable requirements.
- E. Provide means to increase or decrease sensed value and ensure the BAS responds accordingly.
- F. Checkout will be performed via Owner's final graphic screens. If checkout is performed within the programming function of the BAS, it shall be repeated when the final graphic screens are complete and available for use.
- G. Check operation of valve/damper-actuator combination to confirm that actuator modulates valve/damper smoothly throughout stroke to both open and closed positions. Check valve for proper close off.
- H. Provide documentation of the checkout process for each piece of MEP Equipment.

### 3.8. START-UP TESTING

- A. At the conclusion of point-to-point testing/checkout, provide start-up testing of all BAS Components.
- B. Provide start-up of all MEP Equipment. Perform start-up in conjunction with any applicable trades.
- C. Provide start-up testing to ensure all configuration and programming conforms with Sequence of Operation.
- D. Start-up testing will be performed via Owner's final graphic screens. If start-up testing is performed within the programming function of the BAS, it shall be repeated when the final graphic screens are complete and available for use.
- E. Tune PIDs to provide reasonable speed response to change in variables while having stable operation.
- F. Provide documentation of the start-up testing process, including any modifications made to the Sequence of Operation, for each piece of MEP Equipment.

### 3.9. ADJUSTING AND CALIBRATION

- A. Adjust and calibrate all points on the BAS as follows.
- B. Prior to calibration, complete all point-to-point testing/checkout and start-up testing to ensure the BAS is fully functioning.
- C. Calibrations shall be made inside the Niagara wire sheet. Do not calibrate sensors inside the device controller.
- D. Calibrated instrument shall be minimally twice as accurate as the sensor's installed accuracy.
- E. Using calibrated instruments, document actual value (per calibrated instrument) and indicated sensor reading (per the BAS). Adjust using a single point offset or a double-point calibration. Document calibration value(s).
- F. If sensor reading is within the manufacturer's stated accuracy, do not calibrate the sensor. Document actual value and sensor reading.

- G. If sensor is greater than manufacturer's stated accuracy, investigate installation of sensor (i.e., 5-10 pipe/duct diameters downstream, etc), programming of sensor (i.e., SVNTs, range, voltage instead of mA and resistance causing high voltage drop, etc.), transient issues (i.e., turbulence, diffuser blowing on sensor). If investigation uncovers potential source of error, correct sensor installation.
- H. If no errors are found and sensor's accuracy is between 100 and 200% of manufacturer's stated accuracy, provide:
  - 1. Single-point offset for sensors whose readings will vary less than 20% (ex., room temperature).
  - 2. Two-point calibration for sensors whose readings will vary greater than 20%.
  - 3. Document actual value, sensor reading, and offset/calibration values.
- I. If no errors are found and sensor's accuracy is greater than 200% of manufacturer's stated accuracy, replace sensor. Alternatively, provide documentation for approval as to why sensor's error is more than 200% of manufacturer's stated accuracy.
- J. Work with Testing and Balance (TAB) Contractor to input calibrations performed within TAB Contractor's scope of work. Provide dedicated personnel to assist TAB Contractor during their work, provide a fully functioning TAB graphical screen on the BAS for TAB Contractor use, or provide means to adjust TAB via wall module. Assist TAB Contractor with questions regarding TAB graphical screen.
- K. Do not calibrate any sensor which has a guaranteed installed accuracy, such as airflow monitoring stations (AFMS) or water flow sensors.

### 3.10. FUNCTIONAL PERFORMANCE TESTING (FPT) PROCEDURE

- A. Perform point-to-point testing/checkout, start-up testing, adjusting/calibration testing, configuration, and programming on all MEP Equipment and the BAS as a whole to provide a complete and fully functioning BAS.
- B. BAS shall be complete and fully functioning prior to any Functional Performance Testing (FPT). Assist Owner and/or Owner Representatives, which may include but is not limited to the Engineer, Architect, Commissioning Agent (CxA), and/or Testing and Balance (TAB) Firm, with FPT, which may include but is not limited to verification, commissioning, and/or Graphical User Interface (GUI) acceptance testing. Provide dedicated personnel to those activities as specified herein or as requested by Owner.
- C. Provide documentation as specified to prove the BAS is complete and fully functional prior to FPT activities.
- D. At a minimum, perform the following FPT procedures. The following may be achieved within a Commissioning Plan or another FPT as required within the Contract Documents.
  - 1. Provide Owner an agenda and schedule of FPT activities for approval and coordination as part of Action Submittals.
  - 2. Complete all necessary installation to have a complete and fully functional BAS. Provide written notice that BAS is ready for FPT.
  - 3. Demonstrate BAS systems to Owner. Perform FPT including but not limited to Sequence of Operation, point-to-point verification to graphical interface, historical data logging, and alarms.
  - 4. Owner to provide detailed punch list to Contractor.
  - 5. Contractor to repair issues on Owner punch list within five business days.

### 3.11. CLOSEOUT

- A. Upon completion of Functional Performance Testing (FPT), Contractor provides all requirements as specified in 1.13 Close-Out Submittals to Owner.

- B. Contractor trains Owner on all aspects of the BAS including architecture, devices, software, and final Sequences of Operation.
- C. Owner issues letter to Contractor declaring that system is Substantially Complete. Date of this letter starts the Warranty Period.
- D. Final Acceptance. Owner issues letter to Contractor accepting system. Final pay app can be issued for release of any remaining contingency funds.

### 3.12. CONTROL PANELS

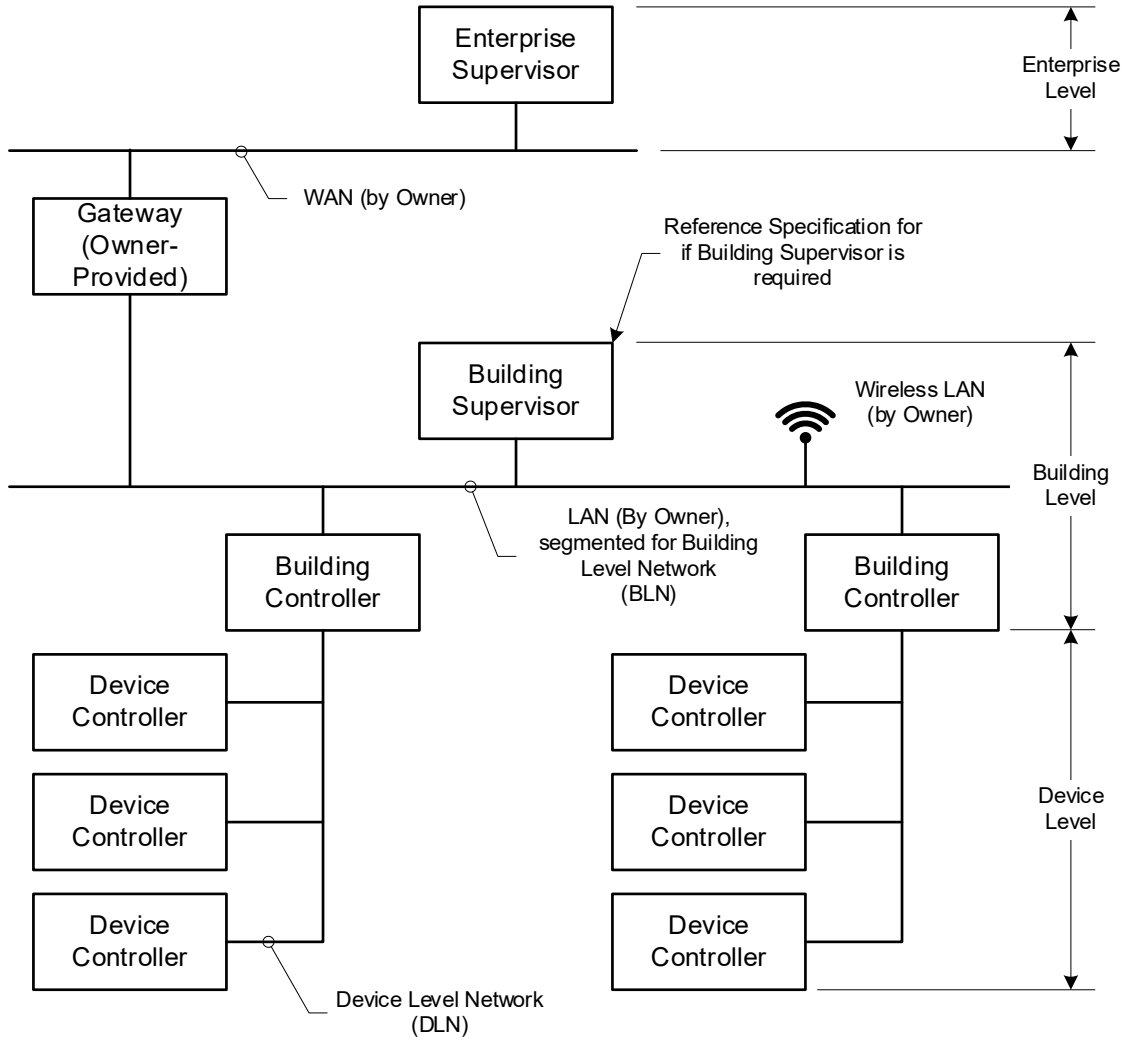
- A. Install Control Panels at locations in accordance with the Contract Documents and/or Owner. Ensure proper service clearances will be achieved at the end of construction. Control Panels without proper service clearances will be relocated at no cost to Owner.
- B. For any Control Panel that exceeds 16 inches in any dimension, provide a trough above/below Control Panel. Trough shall be separated into high and low voltage. Provide a high and low voltage conduit or nipple between trough and Control Panel, sized appropriately for the high and low voltage wiring. All other conduit that serves the Control Panel shall enter/exit the trough. Do not terminate any other conduit(s) to the Control Panel outside of two conduits/nipples identified.
- C. Provide a service loop for all controls wiring. Service loop will be installed in trough (where provided) or inside Control Panel cable tray (where allowed).
- D. Contractor shall extend power to the Control Panel from a junction box or an acceptable location.

### 3.13. GRAPHICS/OPERATOR INTERFACE

- A. The graphics shall comply with the Owner's standards and requirements.

**PART 4 - FIGURES**

**4.1. NETWORK DIAGRAM**



END OF 15900 – BUILDING AUTOMATION SYSTEMS

## 15910 BAS SENSORS AND DEVICES

### **PART 1 - GENERAL**

#### 1.1. APPLICABLE SECTIONS

- A. 15900 Building Automation Systems

### **PART 2 - PRODUCTS**

#### 2.1. GENERAL

- A. Provide BAS Components as indicated in the Contract Documents, Sequence of Operation, control diagrams, points lists, Specifications, or as needed to perform the intended operations consistent with the design intent of the BAS and design/performance intent of the MEP Equipment.
- B. Provide with metal enclosure for all plenum applications. Any sensor mounted in plenum that has a plastic enclosure will be rated for plenum installation or installed in a plenum-rated enclosure.
- C. All sensors shall be vibration and corrosion resistant.
- D. Accuracy statements are written for the specific sensor. Installation shall not degrade accuracy more than double what accuracy statement for sensor requires.
- E. Enclosures:
  - 1. Provide suitable enclosure for BAS Component for ambient conditions encountered by application.
  - 2. NEMA Type 1 or 2 for indoor and protected applications.
  - 3. NEMA Type 3R, 4 or 4X for outdoor and unprotected applications.

#### 2.2. TEMPERATURE SENSORS, STANDARD ACCURACY

- A. Manufacturers:
  - 1. ABB
  - 2. ACI
  - 3. BAPI
  - 4. Distech
  - 5. Honeywell
- B. General Requirements:
  - 1. Sensor shall be thermistor or RTD inherently compatible with BMS.
  - 2. Accuracy:  $\pm 0.5$  deg F over 32 to 158 deg F range.
  - 3. Operating Temperature Range: -40 to 300 deg F.
- C. Outside Air Temperature (OAT) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance, with PVC sun and windscreen as required.
- D. Duct-Mounted Single-Point Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe of length between one-third and two-thirds of the duct width in duct-mounted metal housing with conduit entrance.
- E. Duct-Mounted Averaging Element Temperature Sensor: Multi-point sensor, contained in a flexible copper or woven continuous metallic sheath, with length sized for duct.
  - 1. Provide a minimum of 1 foot of sensing element for every three square feet of duct/coil area. Multiple averaging elements may be required.

2. Averaging elements shall be used where ducts are prone to stratification, and downstream of heating/cooling coils.
  3. Where multiple sensors are provided, sensors may be wired in a series-series, parallel-parallel pattern (requires four or nine sensors) in lieu of multiple inputs.
  4. Plenum rated sheaths are not acceptable.
- F. Wall-Mounted Flat-Plate Temperature Sensor: Stainless steel, flat plate sensor that fits in a standard 2-inch by 4-inch junction box with tamperproof screws. Provide with insulated back.
- G. Thermowell-Mounted Immersion Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe, with three-part moisture protection system, that has minimum length of 20% of the pipe width. Provide machined, single-piece brass or stainless steel thermowell compatible with sensor housing.
- H. Strap-On Piping Temperature Sensor: Sensor with metal clamps to fasten to piping. Strap-on sensors are only acceptable where specifically called for in Contract Documents. Thermowell and insertion sensor shall be installed where strap-on temperature sensor not specifically called for.
- I. Cooler/Freezer Temperature Sensor: Use bullet probe style sensor.

### 2.3. TEMPERATURE SENSORS, MATCHED PAIR

- A. Where two temperature sensors will be used together to calculate a BTU measurement, provide a matched pair.
- B. General Requirements
1. All requirements for Standard Accuracy Temperature Sensors are applicable, except where more stringent below.
  2. Sensor shall be thermistor or RTD with matched transmitter, bath calibrated, 4-20mA output proportional to temperature range and compatible with BAS and 24 Vac/dc power supply.
  3. Differential Accuracy:  $\pm 0.15$  deg F at 70 deg F.
  4. Measurement Range: 32 to 200 deg F.
  5. Range of sensor output shall be appropriate for the application the sensor is installed in. Range of the output shall be set at the factory and shown on the provided documentation.

### 2.4. HUMIDITY SENSORS, STANDARD ACCURACY

- A. Manufacturers
1. ABB
  2. ACI
  3. BAPI
  4. Distech
  5. Honeywell
- B. General Requirements:
1. Laser-trimmed thermoset polymer-based capacitive-type sensor, 4-20mA or 0-10Vdc output proportional to relative humidity range of 0% to 100% and 24 Vac/dc power supply.
  2. Accuracy:  $\pm 2$  percent over 10 to 90 percent range.
  3. Measurement Range: 0-100%.
  4. Operating Temperature Range: -40 to 140 deg F.
- C. Outside Air Relative Humidity (OAH) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance, with PVC sun and windscreen as required.

- D. Duct-Mounted Relative Humidity Sensor: Sensor in duct-mounted plenum-rated housing with conduit entrance.
- E. Wall-Mounted Relative Humidity Sensor: Sensor in white plastic enclosure with insulated back.

#### 2.5. COMBINATION RELATIVE HUMIDITY AND TEMPERATURE SENSORS

- A. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, provide combination relative humidity and temperature sensors. The individual sensors must each meet the specifications details herein.
- B. Where required in the drawings, combination relative and humidity sensors shall have the ability to output additional parameters, including dew point, enthalpy, and wet bulb temperature.

#### 2.6. WALL MODULES AND ROOM SENSORS, STANDARD ACCURACY

- A. General
  - 1. Wall modules and room sensors cover devices which mount on a wall and provide an interface between the MEP Equipment and the occupant.
- B. Manufacturers: Provide a wall module consistent with the manufacturer providing the overall controls.
- C. General Requirements:
  - 1. Wall modules which measure including but not limited to temperature, relative humidity, and/or carbon dioxide must each meet the specifications details herein.
  - 2. Provide with plastic enclosure with display, override switch, override indicator, and setpoint adjustment.

#### 2.7. DRY (AIR) PRESSURE SWITCH

- A. Manufacturers
  - 1. Dwyer
  - 2. Cleveland Controls
- B. General Requirements
  - 1. Diaphragm pressure switch with SPDT contacts.
  - 2. Sensor shall be uni-directional.
  - 3. Manual or automatic reset, in accordance with Contract Documents.
  - 4. Setpoint adjustment knob.
  - 5. Accuracy:  $\pm 2$  percent of full scale output.
  - 6. Measurement Range: 0 to 12 in wg.
  - 7. Operating Temperature Range: -4 to 185 deg F.
- C. "Paddle-style" air flow switches are not allowed. Use dry pressure switch in lieu of paddle.

#### 2.8. DRY (AIR) PRESSURE SENSOR, STANDARD ACCURACY

- A. Manufacturers
  - 1. ACI
  - 2. Honeywell
  - 3. Setra
  - 4. Veris
  - 5. ABB
- B. General Requirements

1. Diaphragm pressure transducer and amplifier type sensor, 4-20mA or 0-10Vdc output proportional to pressure range and compatible with BMS system and 24 Vac/dc power supply.
  2. Sensor shall be uni- or bi-directional for application as stated below.
  3. Sensor shall have local display.
  4. Accuracy:  $\pm 1$  percent of full-scale output/selected range.
  5. Measurement Range: See applications below.
  6. Operating Temperature Range: -4 to 140 deg F.
  7. Burst pressure: 5 psid.
- C. Duct-Mounted Static Pressure Sensors:
1. Uni-directional.
  2. Measurement Range: 0 to 5 in wg. for low and medium pressure applications and higher as required for high pressure applications.
- D. Room Pressure Sensors:
1. Bi-directional.
  2. Measurement Range: -0.2 to 0.2 in wg.
  3. Provide with surge damper (Amphenol SD-01 or equivalent) and room static pressure pickup with fine stainless steel mesh filter.
- E. Building Pressure Sensors:
1. Bi-directional.
  2. Measurement Range: -0.2 to 0.2 in wg.
  3. Provide outside air reference kit, (Dwyer A-306 or equivalent), with tubing, mounting bracket and required hardware.
  4. Provide with surge damper (Amphenol SD-01 or equivalent) and room static pressure pickup with fine stainless steel mesh filter.
- F. Air Filter/Coil Differential Pressure Sensors:
1. Uni-directional.
  2. Measurement Range: 0 to 2 in wg and higher as required.
  3. Provide with static pressure probe(s).
- 2.9. WET (WATER) PRESSURE SWITCH
- A. Manufacturers
1. Ashcroft
- B. General Requirements
1. Diaphragm pressure switch with SPDT contacts.
  2. Sensor shall have stainless steel wetted components in a weatherproof wiring housing.
  3. Sensor shall be uni-directional.
  4. Manual or automatic reset, in accordance with drawings.
  5. Setpoint adjustment knob.
  6. Accuracy:  $\pm 2$  percent of full scale output.
  7. Measurement Range: 0 to two times the setpoint or anticipated pressure.
  8. Operating Temperature Range: -20 to 150 deg F.
- C. "Paddle-style" water flow switches are not allowed. Use wet pressure switch in lieu of paddle.



## 2.10. WET (WATER) PRESSURE SENSOR

### A. Manufacturers

1. Senva
2. Setra
3. Veris
4. ABB

### B. General Requirements

1. Diaphragm pressure transducer and amplifier type sensor, 4-20mA or 0-10Vdc output proportional to pressure range and 24 Vac/dc power supply.
2. Sensor shall have stainless steel wetted components in a weatherproof wiring housing.
3. Sensor shall be uni-directional, unless bi-directional required for reversing flow.
4. Sensor shall have local display.
5. Accuracy:  $\pm 0.25$  percent of full-scale output/selected range.
6. Measurement Range: See applications below.
7. Operating Temperature Range: See applications below.
8. Proof Pressure: two times rated input pressure, or greater.
9. Burst Pressure: five times rated input pressure, or greater.

### C. Water "Gauge" Pressure Sensors:

1. Measurement Range: 0 to two times the setpoint or anticipated pressure.
2. Operating Temperature Range: 0 to 175 deg F.

### D. Water Differential Pressure Sensors:

1. Measurement Range: 0 to two times the setpoint or anticipated pressure.
2. Operating Temperature Range: 0 to 175 deg F.

### E. Provide with four or five valve manifold. Sensor to be connected to manifold at factory.

## 2.11. CURRENT SWITCHES/TRANSDUCERS

### A. Manufacturers

1. ACI
2. Setra
3. Veris
4. ABB

### B. General Requirements

1. Sensor shall be rated for their associated motor load and voltage, have input and output isolation, and have LED indication of status.
2. Sensor shall be selected based on application, including but not limited to standard 60 hertz motors, variable speed drive, or ECM.
3. Accuracy:  $\pm 2$  percent of full-scale output.
4. Measurement Range: 0 to two times the anticipated current.
5. Operating Temperature Range: 5 to 140 deg F.

### C. Current Switch (CS):

1. Self-powered current switch with N.O. contacts.
2. Provide with adjustable trip point where indicated in Contract Documents, or as required for proper operation for application.

### D. Current Transducer (CT):

1. Sensor with 4-20mA or 0-10Vdc output proportional to current draw and 24Vac/dc power supply.

## 2.12. CARBON DIOXIDE SENSORS

### A. Manufacturers

1. Honeywell
2. Vaisala
3. Veris
4. ABB

### B. General Requirements

1. Non-dispersion infrared (NDIR) type sensor, 4-20mA or 0-10Vdc output proportional to carbon dioxide (CO<sub>2</sub>) range and 24 Vac/dc power supply.
2. Sensor shall have local display.
3. Accuracy:  $\pm 2$  percent of reading, or 30 ppm, whichever higher.
4. Measurement Range: 0 to 2000 ppm.
5. Operating Temperature Range: 32 to 122 deg F.
6. Standard Calibration: No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing an automatic unoccupied period calibration.

C. Wall-Mount Carbon Dioxide Sensors: Sensor with plastic enclosure that fits on a standard 2-inch by 4-inch junction box.

D. Duct-Mount Carbon Dioxide Sensors: Sensor with sampling tube, duct-mounted metal housing with conduit entrance.

E. Where CO<sub>2</sub> is provided beside temperature and/or humidity sensors, it shall be provided separately and not combined into a single sensor.

## 2.13. AIRFLOW MEASUREMENT STATION (AFMS)

### A. Manufacturers

1. Ebtron

### B. General Requirements

1. Thermal dispersion type flow sensor, composed of one or more sensor probes (multiple sensors per probe) and transmitter, 4-20mA or 0-10Vdc output proportional to flow range and 24 Vac/dc power supply.
2. Measurement will be made using the principle of thermal dispersion. Provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node. Thermal dispersion devices that indirectly heat a thermistor are not acceptable. Other measurement technologies are not acceptable.
3. Sensor probe tubes and mounting brackets shall be constructed of gold anodized, 6063 aluminum alloy, 304 stainless steel, or 316 stainless steel.
4. Internal wiring in probes shall be resilient to exposure of moisture and not effect sensor operation.
5. Sensor probe shall be comprised of multiple sensors, with calibration data stored in the cable connecting plug, such that switching transmitters will automatically read corresponding calibration and sensor data. Quantity of sensors per probe and quantity of probes shall vary based on duct/fan configuration to provide the required accuracy.
6. Accuracy:  $\pm 3$  percent of reading over full scale, when installed in accordance with manufacturer guidelines.  $\pm 5$  percent of reading over full scale for outdoor air intakes,

when installed in accordance with manufacturer guidelines. Accuracy is for installed air flow monitoring sensor, not for individual sensors in each probe.

7. Measurement Range: 0 to 5,000 feet per minute (fpm).
8. Operating Temperature Range: Probes: -20 to 160 deg F. Transmitter: -20 to 120 deg F.
9. Sensing elements will be NIST traceable.
10. Transmitter:
  - a. Heavy-duty construction with LED display with 4-20mA air flow and temperature output signals. Outputs may be field configured for additional signals.
  - b. Capable of communicating with BAS on communication protocol as specified in 15900
  - c. Transmitter shall generate alarms for individual sensor errors and transmit over the BMS network.
  - d. Transmitter will be provided with Bluetooth low-energy interface card, capable of transmitting information to Android or iOS devices.
- C. Duct Air Flow Measuring Stations: Probes will be ordered specific to duct as installed in field.
- D. Fan Inlet Air Flow Measuring Stations: The sensing element shall be specifically designed to measure air flow of a centrifugal fan at the inlet cone. Coordinate mounting style with fan selection and manufacturer recommendations. For double-inlet fans, provide one set of elements for each inlet.

#### 2.14. INSERTION TURBINE WATER FLOW METERS

- A. Manufacturers
  1. Onicon F-1000 series
- B. General
  1. Provide with NIST traceable, wet calibrated flow-measuring element, integral transmitter (4-20mA or 0-10Vdc output proportional to flow range), installation valves, depth gage, calibration certificate, and attached tag indicating calibration information.
  2. Flow meter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown.
  3. Provide power from 24 Vac/dc power supply.
  4. Contractor shall be responsible for selecting flow meter options submitted based on application. Flow meter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions, and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.
  5. Single or dual axial insertion turbine design with electronic impedance-based sensing circuit. Dual insertion turbine shall incorporate two contra rotating turbines and an averaging circuit to reduce measurement errors due to flow distortions, such as swirl, when installed in piping configurations with reduced straight run.
    - a. Coordinate single or dual turbine requirements with as-built conditions to ensure accuracy is achieved as specified.
  6. 316L stainless steel construction.
  7. Maximum pressure rating: 400 psig or greater.
  8. Maximum temperature rating: 280°F or greater.
  9. Accuracy:  $\pm 2$  percent of reading from 0.4 to 20 fps, when installed in accordance with manufacturer guidelines.
  10. Flow range: 0 to 20 fps

11. Provide with installation kit appropriate for application.

C. Application

1. Chilled water, chilled glycol, hot water, or any other media which contains minimal particulate.

2.15. INSERTION ELECTROMAGNETIC WATER FLOW METERS

A. Manufacturers

1. Onicon F-3500 Series

B. General

1. Provide with NIST traceable, wet calibrated flow-measuring element, integral transmitter (4-20mA or 0-10Vdc output proportional to flow range), installation valves, depth gage, calibration certificate, and attached tag indicating calibration information.
2. Flow meter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown.
3. Provide power from 24 Vac/dc power supply.
4. Contractor shall be responsible for selecting flow meter options submitted based on application. Flow meter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions, and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.
5. Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.
6. 316L stainless steel construction.
7. Maximum pressure rating: 400 psig or greater.
8. Maximum temperature rating: 200°F or greater.
9. Accuracy:  $\pm 1$  percent of reading from 2 to 20 fps, when installed in accordance with manufacturer guidelines.
10. Flow range: 0 to 20 fps
11. Provide with installation kit appropriate for application.

C. Application

1. Condenser water or any other media which contains particulate.

2.16. BTU (ENERGY) METERS

A. Manufacturers

1. Onicon System 10

B. General

1. Water flow meter, dual temperature sensors, and transmitter, 4-20mA or 0-10Vdc output proportional to flow range and each temperature (3 analog outputs total), and 24 Vac/dc power supply.
2. Provide water flow meter in accordance with the specification herein.
3. Provide matched temperature sensors in accordance with the specification herein.
4. Transmitter
  - a. Provide with local display and operator interface. Display shall visually indicate instantaneous flow rate, supply temperature, return temperature, thermal energy flow rate (MBH).
  - b. Capable of communicating with BAS on communication protocol as specified in 15900

## 2.17. THERMOSTATS

### A. Manufacturers

1. ACI
2. Honeywell
3. ABB
4. Schneider Electric

### B. General

1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF", "FAN HIGH-MED-LOW-OFF", or as applicable.
2. Mount on standard junction box.
3. Thermostat portion must meet the specifications details herein as required for application.

### C. Digital Stand-Alone Thermostat

1. Electronic, solid-state, microcomputer-based room thermostat.
2. Automatic switching from heating to cooling.
3. PID control to minimize overshoot and deviation from setpoint.
4. Set up for four separate temperatures/periods per day, with individual programming for each day of the week (4 programs per day, 7 days per week, 28 potential programs).
5. Instant override of setpoint for continuous or timed period from 1 hour to 31 days.
6. Short-cycle protection.
7. Selection features include degree F or degree C display, 12- or 24-hour clock, keypad disable, and fan on-auto-circulate.
8. Powered off unit 24Vac transformer, with solid-state memory in which programming is retained on power failure. Battery acceptable only for time and date upkeep during power failure.
9. Thermostat display features include the following: time of day, actual room temperature, programmed temperature, programmed time, duration of timed override, day of week, and system mode indications include "heating," "cooling," "off," "fan auto," "fan circulate," and "fan on."
10. Combination Thermostat, Humidistat, Carbon Dioxide, and/or Occupancy Sensor: Where there is a requirement for a thermostat with humidistat, carbon dioxide, and/or occupancy sensing functions at the same location, provide combination unit. The individual sensors must each meet the specifications details herein.
11. Provide remote sensing element (electronic sensor) as required for application.

### D. Low-Voltage, On-Off Thermostats

1. 24Vac, bimetal-operated, mercury-free, heat anticipator, concealed set-point adjustment, space temperature indicator, 55 to 85 deg F setpoint range, and 2 deg F maximum differential.
2. Selector Switch: Integral, manual on-off-auto.

### E. Line-Voltage, On-Off Thermostats

1. Line voltage listed for electrical rating, bimetal-operated, mercury-free, open contact or bellows-actuated, snap-switch or equivalent solid-state type, heat anticipator, concealed set-point adjustment, space temperature indicator, 55 to 85 deg F setpoint range, and 2 deg F maximum differential.
2. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.

3. Selector Switch: Integral, manual on-off-auto.
  4. Combination Thermostat and Fan Switches: Push-button or lever-operated fan switch.
- F. Freezestat/Low-Limit Duct Thermostat (LTD)
1. Manual reset switch.
  2. Snap-acting SPDT with gas/refrigerant filled copper capillary that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint. Sensing range 15 to 55 deg F.
  3. Bulb Length: Sized for duct/coil with minimum 5 feet.
  4. Quantity: Provide a minimum of 1 foot of sensing element for each square foot of duct/coil area. Multiple Low-Limit Thermostats may be required.
- G. High-Limit Humidistat
1. Snap acting SPDT, duct or room mount, automatic reset switch that trips if humidity sensed is equal to or above setpoint. Sensing range 15 to 95% relative humidity.
- H. Strap-On Piping Aquastat Temperature Sensor
1. Snap acting SPDT, pipe mount, automatic or manual reset switch (as indicated in Contract Documents) that trips if temperature sensed is equal to or above setpoint. Sensing range appropriate for application.

## 2.18. RELAYS

- A. Manufacturers
1. IDEC
  2. Functional Devices
  3. Veris
  4. ABB
- B. General Requirements
1. Electrically rated for application, minimally SPDT with 10A (resistive) contacts.
  2. Provide with LED indicator light.
  3. Provide with hand-off-auto (HOA) unless otherwise specified. HOA not required if controller has internal HOA or output being controlled has HOA (i.e. VFD).
  4. Plenum rated where required.
- C. BAS Panel-Mounted Relays: "ice-cube" / socket style with mounting base and replaceable relay. Relays in panel will be screw terminal terminations; relays with wiring whip from factory are not allowed for panel mounting.
- D. Nipple-Mounted Relays: enclosed relay compatible with conduit knockout. Acceptable for field use. With or without factory-provided wiring whip.
- E. Track-Mounted Relays: acceptable for use in terminal unit control panels. Screw terminal terminations. Track-mounted relays are not to be installed in field unless inside an equipment control panel (i.e., no track-mounted relays in electrical boxes).
- F. Combination Motor Starter / Current Switch Relays: allowed only for single-phase equipment and must be mounted such that pilot light is exposed (i.e., combination motor starter / current switch relays which install inside of motor starter/VFDs are not allowed). The individual sensors must each meet the specifications details herein.

## 2.19. ADDITIONAL SENSORS AND DEVICES

- A. Shaft-Mounted Limit Switches: SPDT/DPDT mercury-free, gravity-actuated mechanical switch with adjustable shaft connection.
- B. Whisker Limit Switches: SPDT/DPDT mechanical whisker switch with adjustable trim arm.

- C. Condensate Drain Pan Overflow Safety Switch: Low-voltage, float-type safety switch designed for condensate drain pan high-level alarm for unit shutdown and alarming. Little Giant Pump/Franklin Electric (ACS series) or equal. Whisker switch with foam float is not acceptable.
- D. Water Leak Detection Alarm: Adjustable-height multi-point water detection sensor constructed to be corrosion and abrasion resistant and configured for normally open or normally closed as required by the application with 24Vac/dc power supply. Provide remote-mounted sensing probe and cable as needed for each application. Operating Temperature Range: -40 to +185 deg F.
- E. Emergency Stop Buttons: ADA-compliant, red emergency pushbutton in yellow polycarbonate plastic enclosure with clear flip-up cover and stainless steel backplate. Button shall be reset by twisting or pulling out the button; a procedure that requires disassembly or a key is not acceptable. 120V or 24 V as needed. Provide label with indication of operation (ex. "Boiler E-Stop"). Safety Technology International (STI) Stopper Station series or equal.

## 2.20. ELECTRONIC ACTUATORS

- A. Manufacturers: All valve actuators shall be supplied from a single manufacturer. All damper actuators shall be supplied from a single manufacturer. Provide actuators manufactured by one of the following:
  1. Belimo
  2. Honeywell
  3. ABB
  4. Schneider Electric (TAC Dura-Drive)
- B. General
  1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
  2. Actuators shall operate related valve(s)/damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the valve/damper is subjected.
  3. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the designed pump/fan shutoff pressure as a minimum requirement.
  4. Select actuators to fail in desired position in the event of a power failure. See Contract Documents for power failure modes.
  5. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
  6. Type: Motor operated, with gears, electric and electronic.
  7. Voltage: 24Vac unless otherwise specified. 120V actuators may be allowed if coordinated by BAS Contractor with Electrical Contractor to provide local disconnect and power. Circuit must be fed from the same power panel as the MEP Equipment or Control Panel and a spare circuit must be available.
  8. Power: Contractor is responsible for sizing control transformers based on the VA of the actuator(s) selected.
  9. Provide electronic overload protection throughout the entire operating range in both directions.
  10. Coupling: V-bolt and V-shaped, toothed cradle. Bolt and set screw method of attachment is unacceptable.
  11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

12. Two-Position Actuators: Single direction, spring return or non-spring return type.
13. Modulating Actuators:
  - a. Capable of stopping at all points across full range and starting in either direction from any point in range.
  - b. Control Input Signal:
    - A) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input, the actuator remains in the last position.
    - B) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 0-5Vdc, 0-10Vdc, 1-5Vdc, 2-10Vdc, and 4-20mA signals.
  - c. Floating control actuators shall be allowed only for damper and valve control for room terminal units where there is not a room pressurization requirement. See General Requirements for definition of those spaces. Use of floating controls must be specifically requested by Contractor for specific spaces and reviewed by Owner. Submission of floating control actuators without specific comment by Contractor for spaces and the resulting review by Owner does not constitute approval for use.
  - d. Pulse width modulation (PWM), or any other analog signal that is not specified above is not allowed.
14. Position Feedback: Where indicated, equip two-position actuators with auxiliary switches (SPDT) for remote monitoring of open and/or closed position. Point of open and/or closed position can be adjusted over the actuators range of operation (0-100%). Where indicated, equip modulating actuators with a position feedback through current and/or voltage signal for remote monitoring.
15. Fail-Safe: Where indicated, provide actuator to fail via a mechanical spring return mechanism, to drive controlled device to an end position (open or close) on loss of power. Electronic fail-safe is not allowed, unless specifically reviewed and accepted by Owner. Provide external, manual gear release on non-spring return actuators.
16. Temperature Rating:
  - a. Standard Dampers and Valves: -22 to +122 deg F.
  - b. Smoke Dampers: -22 to +250 deg F.
17. Provide actuator enclosure with a heater and thermostat where required by application.
18. Stroke Time:
  - a. Normal: 120 seconds or less from fully closed to fully open, or fully open to fully closed.
  - b. Fast-Acting: 12 seconds open, 5 seconds closed unless otherwise noted.
- C. Damper Actuators
  1. The total damper area operated by an actuator shall not exceed 80 percent of damper manufacturer's maximum area rating.
  2. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison off a single control signal.
  3. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
  4. Use shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.



5. Actuator will mount directly to damper with coupler as described above. No foot mount kits, jackshafts, or linkages shall be used.
  6. Sizing: Size for running torque calculated as follows:
    - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sqft. of damper.
    - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sqft. of damper.
    - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sqft. of damper.
    - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sqft. of damper.
    - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1,000 to 2,500 fpm: Increase running torque by 1.5.
    - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2,500 to 3,000 fpm: Increase running torque by 2.0.
- D. Smoke and Combination Fire/Smoke Damper Actuators
1. Actuator shall come connected to damper as a rated assembly, sized per the damper manufacturer's requirements, and meet the specifications herein.
  2. Actuators operating in smoke control systems shall comply with governing code and NFPA requirements.
- E. Valve Actuators
1. Valve actuators will be direct coupled "rotary-style" unless otherwise specified. Where required, direct coupled "linear-style" actuators may be used.
  2. Sizing
    - a. Hydronic: Size for torque required to achieve valve close off at 150% of maximum pump differential pressure.
    - b. Steam: Size for torque required to achieve valve close off at 150% of steam design pressure.

## 2.21. CONTROL VALVES

### A. General

1. Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
2. Control valves assemblies shall be provided and delivered from a single manufacturer as a complete assembly, with the actuator installed at the factory.
3. Control valves shall be two- or three-way as specified in Contract Documents.
4. Provide with extended neck as required to accommodate insulation thicknesses.
5. Refer to Division 15 for general information about valve construction and installation.

### B. Hydronic Ball-Style Control Valves

1. Manufacturers
  - a. Belimo (CCV Series)
  - b. Honeywell (VB Series)
2. Construction
  - a. 2-Inch NPS and Smaller: 350 psi at 250 deg F brass/bronze body, stainless steel ball with matching blow-out proof stem, full port with stainless steel or composite characterizing insert, Teflon seats, dual EPDM O-ring seals, solder or threaded ends.
  - b. 2 1/2-Inch NPS and Larger: 175 psi at 250 deg F iron body, stainless steel ball and matching blow-out proof stem, full port with stainless steel or composite characterizing insert, Teflon seats, dual EPDM O-ring seals, ANSI Class 125/150 flanged ends.

- c. ANSI class IV seat leakage for two-way, ANSI class IV seal leakage for three-way A-Port and class III for B-Port.
  - 3. Flow Characteristics
    - a. Two-way two-position valves shall be full port.
    - b. Two-way modulating valves shall have equal percentage characteristics.
    - c. Three-way valves shall have equal percentage characteristics on A-Port and linear characteristics for B-Port. Bypass applications shall have linear percentage characteristics.
  - 4. Sizing
    - a. Two Position: Line size or size using a 1 psig pressure differential.
    - b. Two-Way Modulating: Size using 4 psig or equal to the load pressure drop, whichever is greater.
    - c. Three-Way Modulating: Size using 4 psig or equal to the load pressure drop, whichever is smaller.
    - d. Effective Cv: for any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect. Provide effective Cv on submittal.
- C. Hydronic Butterfly-Style Control Valves
  - 1. Manufacturers
    - a. Belimo (HD Series)
    - b. Honeywell (VFF Series)
  - 2. Construction
    - a. 2 to 12-Inch NPS: Class 125/150 cast-iron full-lugged body, stainless steel disc, EPDM seat and extended neck. Disc-to-stem connection shall utilize an internal spline.
    - b. 14-Inch NPS and Larger: Class 125/150 cast-iron full-lugged body, stainless steel disc, EPDM seat and extended neck. Disc-to-stem connection shall utilize a dual-pin method.
    - c. Leakage: 200 psid zero leakage for 2 to 12-inch NPS and 150 psid zero leakage for 14-inch NPS and larger.
  - 3. Sizing
    - a. Two Position: Line size or size using a 1 psig pressure differential.
    - b. Two-Way Modulating: Size using 3 psig or equal to the load pressure drop, whichever is greater. Size for the design flow with the disc at 60-degree open position and the design velocity less than 12 FPS.
    - c. Effective Cv: for any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect.
- D. Pressure-Independent Hydronic Ball-Style Control Valves
  - 1. Manufacturers
    - a. Belimo (PIQCV up to 3/4"; ePIV for 1" and up)
  - 2. General
    - a. Valve shall meet all the requirements set forth in the Hydronic Ball-Style Control Valve section, in addition to the requirements below.
    - b. Operating Differential Pressure Range: 5 to 50 psid or better.

- c. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valves shall accurately control the flow from 0 to 100% full rated flow.
- 3. Construction
  - a. Mechanical pressure regulation style PIC valves shall have factory installed pressure/temperature test ports (Pete's Plugs) across the pressure regulator at the factory.
  - b. Pressure independent control valves 1" NPT or larger may use ultrasonic flow measurement. The ultrasonic flow meter will meet the specifications herein.
- 4. Flow Characteristics: see Hydronic Ball-Style Control Valves.
- 5. Sizing
  - a. Valve shall be sized at line size for the GPM specified of MEP Equipment.
  - b. Provide minimum and maximum full-open pressure drop of valves.

### **PART 3 - EXECUTION**

#### **3.1. GENERAL INSTALLATION**

- A. Install aspirating guards on wall-mounted devices in the following locations:
  - 1. Building entrances.
  - 2. Public areas.
  - 3. Where indicated on construction documents.
- B. Exposed wire nuts, including in plenum, will not be acceptable. All connections will be made inside a rated enclosure.
- C. Install labels and nameplates to identify control components according 15190.
- D. Install hydronic instrument wells, valves, and other accessories according to Division 15.
- E. Install refrigerant instrument wells, valves, and other accessories according to Division 15.
- F. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- G. Coordinate fire alarm relay connections to the fire alarm system with the fire alarm installer.
- H. Where sensors have a display, mount such that display can be read from ground.
- I. Install sensors in visible and accessible areas. Do not hide sensors on top of ductwork or insulate over sensors.
- J. For sensors on rigid insulation for duct or piping, install sensor prior to insulation. Sensors installed after insulation will be required to cut and seal insulation around sensor.
- K. Sensors requiring an external power source shall use DC power from switching DC power supply. Do not use alternating current for sensors unless specifically required by the manufacturer. Do not use on-board DC power for sensors unless specifically required by the manufacturer.

#### **3.2. TEMPERATURE/HUMIDITY/WALL MODULE AND ROOM SENSORS INSTALLATION**

- A. Verify location of thermostats, humidistats, and other exposed control sensors with Contract Documents and room details before installation. Install devices 48 inches above the floor per ADA requirements. The location(s) to be selected by Owner. No sensor shall be mounted until the Owner and/or Owner Representatives give specific location instructions. Do not

install sensor(s) on the inside of exterior building walls (including column fur outs) unless explicitly approved by Owner.

- B. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
- C. Install outdoor air temperature and humidity sensors on north-facing wall at designated location. If sensor cannot be placed on north wall, submit RFI for approved location and provide with PVC sun shield and windscreen.
- D. Single-point temperature sensors may be used in ducts where there is no air stratification possibilities. Sensor shall be mounted sufficiently downstream to allow for sufficient mixing, five to ten duct diameters at a minimum.
- E. Install mixing plenum sensors in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip.
- F. Thermowells to be installed in piping. Contractor to “stub-up” any thermowell which is too long to install directly into piping. Install heat-conducting fluid in thermowell prior to installing sensor.
- G. Install heat-conducting fluid where strap-on temperature sensors contact piping. Sand and clean piping prior to installation. Insulate around sensor.
- H. Install cooler/freezer sensors in rubber clamp to isolate sensor from surrounding metal. Run conduit inside cooler/freezer for sensor away from door and storage racks. After sensor has been checked out, seal all penetrations with low expansion insulating foam. Coordinate installation with cooler/freezer vendor.
- I. Install humidity sensor in areas where relative humidity will not rise above 90% RH. If area will have high humidity consistently, relocate to different area and use dewpoint/psychrometric calculations to calculate relative humidity of the area required.
- J. Wall Modules
  - 1. Limit setpoint adjustment to  $\pm 3$  deg F unless otherwise specified on the Drawings.

### 3.3. PRESSURE SENSOR INSTALLATION

- A. Supply (Positive) Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube/probe. Make pressure tap connections according to manufacturer's recommendations.
- B. Return (Negative) Duct Static Pressure. Pipe low-pressure tap to duct using a pitot tube/probe. Make pressure tap connections according to manufacturer's recommendations.
- C. Room Pressure: Pipe appropriate pressure sensor port (positive space: high pressure, negative space: low pressure) to room. Pipe opposite pressure point to reference outside of room. Connect to stainless steel mesh snubber mounted to white 2 in by 4 in plate at locations on drawings.
- D. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through outside air reference kit. Mount kit per manufacturer's instructions. Pipe high-pressure port to stainless steel mesh snubber mounted to white 2 in by 4 in plate at locations on drawings.
- E. Pressure transducers, except those controlling VAV boxes, shall be located in Control Panels, not on MEP Equipment or on ducts. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
- F. Do not install tees for TAB purposes in air pressure tubing. Remove tees where found.
- G. Install differential pressure sensor valve manifold at eye level. Provide hard copper tubing from water mains to valve manifold; soft copper not allowed. Provide isolation valves in tubing prior to valve manifold.

#### 3.4. CURRENT SWITCHES/TRANSDUCER INSTALLATION

- A. Wire may be “wrapped” around CS/CT to obtain better status indication.
- B. CS/CTs requiring commissioning/startup will be done per manufacturer installation instructions.

#### 3.5. AIR FLOW MEASUREMENT STATIONS (AFMS) INSTALLATION

- A. Install AFMS in locations indicated and required to perform the Sequences of Operation. Install AFMS in accordance with the manufacturer’s recommendations.
- B. Do not install AFMS sensors and probes until all sanding and grinding activities are complete to protect them from accumulating dust and debris.
- C. Prior to ordering, measure actual duct size as installed in field and provide to vendor.
- D. Mount transmitter at eye level. Measure distance from probe to transmitter and order wire whip of sufficient length to reach. Install probe wire whip in conduit of sufficient size for connector to pass through.

#### 3.6. THERMOSTATS

- A. Install Freezestat/Low-Limit Duct Thermostat (LTD) in ducts and plenums in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip. Provide rows at 12 inch spacing; the element covers a maximum of 6 inches above and below sensing element. At the bottom of the duct or plenum, the row with the tail end of the sensing element shall be a maximum of 6 inches from the bottom.

#### 3.7. WATER FLOW AND BTU METER INSTALLATION

- A. Install water flow meters in locations indicated to perform the Sequences of Operation. Install water flow meter in accordance with the manufacturer’s recommendations.
- B. Do not install AFMS sensors and probes until all sanding and grinding activities are complete to protect them from accumulating dust and debris.
- C. Prior to ordering, measure actual pipe size and verify furnished material as installed in field and provide to vendor.
- D. Mount transmitter at eye level. Measure distance from probe to transmitter and order wire whip of sufficient length to reach. Install probe wire whip in conduit of sufficient size for connector to pass through.
- E. Provide installation kit (i.e., threadolet, nipple/standoff, pipe tee, isolation valve, etc) to Mechanical Contractor for installation. Kit will be specific to the application. Installation accessories which are not provided by the vendor will not be acceptable.

#### 3.8. RELAYS

- A. Nipple-mount relays will be mounted at a location where pilot light is visible from floor.

#### 3.9. VALVES, DAMPERS, AND ELECTRONIC ACTUATORS INSTALLATION

- A. Wire parallel actuators according to manufacturer's recommendations.
- B. Dampers and Damper Actuators
  - 1. Install automatic dampers according to Division 15.
  - 2. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.
  - 3. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately the 5° open position, manually close the damper, and then tighten linkage.
  - 4. Provide necessary mounting hardware and linkages for actuator installation.

5. Install damper motors on outside of duct in climate controlled areas, including mechanical rooms. Provide sufficient standoff/offset of damper actuator from ductwork to allow for insulation behind actuator.
  6. Where clearance cannot be maintained, locations exposed to outdoor temperatures, or actuator is inside ductwork, provide 12 inch by 12 inch access door per specifications for any actuator inside of ductwork.
- C. Control Valves and Valve Actuators
1. Provide sufficient standoff/offset of valve actuator from piping to allow for insulation of valve.
  2. PIC Valves
    - a. Where not provided from the factory, install pressure/temperature test ports (Pete's Plugs) for testing of pressure differential across the PIC valve.
    - b. For PIC valves with electronic flow metering, coordinate with mechanical contractor to ensure 5 pipe diameters of straight pipe entering valve.
  3. Steam Valves
    - a. Mount actuators at a minimum 30 degree angle compared to vertical. Do not mount actuator directly above steam valve or piping.

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART I: GENERAL**

Control system contractor shall be responsible for selection of the proper control valves including line size, pressure rating, flow-coefficient, shutoff rating and allowable leakage factor. Valves will be turned over to the Division 15 Contractor for installation.

Modulating water valves shall be sized for nominal 5 psi pressure drop and close off. All 2-way valves shall have contoured or characterized throttling plugs with linear (for steam applications) or equal percentage characteristics.

The controls contractor shall calculate the required Cv for each valve. Valve Cv shall be within 100 percent to 125 percent of the Cv calculated.

Fan coil valves and AHU central station actuators shall operate from either a 0-10Vdc or a 4-20ma signal.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Belimo
2. Delta
3. Approved equal

**2.2 CONTROL VALVES**

- A. Valves 1/2 inch through 2 inches shall be ball valve type assemblies industrial quality with bronze bodies and NPT screw type and shall be rated for 600 psig (40 bar) working pressure - or two-way and 400 psig (27 bar) for three-way. The operating fluid temperature range shall be 20' F to 2500 F (-70C to 1200C).
- B. The actuator and its mounting plate shall be capable of being repositioned on the square mounting bracket in 90 degree increments parallel or perpendicular to the pipe. Non-metallic thermal isolation standoffs shall separate mounting plate from actuator with high temperature materials rated for continual use at greater than the application temperature. Valve assemblies without thermal isolation as described above are not acceptable.
- C. The mounting bracket shall be of rigid structural metal incorporating a shaft of stainless steel positioned parallel and perpendicular to the packing and stem to prevent lateral or rotational forces from affecting the stem and its packing. The mounting bracket shall be positioned so as to allow the insulation of the valve body and bracket to allow removal of the actuator without disturbing the insulation. Valves shall have either ISO-5211 style mounting pads or machined mounting surfaces. The shaft shall be supported by an upper bearing.
- D. All control ball valves shall be furnished with a 316 stainless steel ball & stem and carbon and graphite reinforced Teflon O seats and seals.
- E. Ball valves for low pressure steam applications shall have 316 stainless steel ball, stem, and drive shaft and rated at a maximum of 600 psi working pressure. Valves shall be installed in the piping at 45 degree angle from vertical. Valve and actuator mounting bracket shall be fully insulated.
- F. The valves shall have a blow out proof stem design.

- G. Each valve shall be functionally tested by the valve manufacturer.
- H. Flow type for modulation shall have equal percentage and linear flow characteristics for two-way and three-way valves, respectively.
- I. Two-way stem packing shall consist of stacked 'V' ring and spring (live) loaded packing requiring no maintenance. Three-way stem packing shall consist of EPDM O-ring requiring no maintenance and no adjustment to meet complete operating life. Valves requiring packing adjustment throughout the life of the valve are unacceptable.
- J. Valves 3 inches and larger shall be butterfly valves.
- K. Butterfly valves shall be threaded lug type suitable for dead-end service and for modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, have flanged-end connections, and EPDM seats suitable for temperatures from minus 20 degrees to plus 250 degrees F. All valves shall have a manual means of operation independent of the actuator. Provide valve manufacturer's insulation casing.
- L. Manufacturer shall provide a two year "no hassle" unconditional warranty from date of installation.

### 2.3 CONTROL VALVE ACTUATORS

- A. The actuator manufacturer shall have ISO 9001 quality certification.
- B. Actuators shall be Underwriters Laboratories Listed under Standard 873 and Canadian Standards Association Class 4813 02. Actuators shall have European Community (CE) certification.
- C. Actuators used near outdoor air streams shall have NEMA type 2 (IP54) housings for water and moisture resistance.
- D. Actuators shall be mounted on the valve by the manufacturer.
- E. Actuators shall be applied according to the manufacturer's specifications.
- F. Actuators shall be fully modulating or 2-position (with fail-safe mechanical spring return) as indicated on drawings.
- G. The valve actuator shall be capable of providing the minimum torque required for proper valve close-off for the required application.
- H. Each actuator shall have current limiting circuitry or microprocessor overload protection incorporated in its design to prevent damage to the actuator. End of travel switches are not acceptable.
- I. Actuators shall have mechanical spring return for fail safe mode where specified. Battery backup units or storage capacitor type units contained within the individual actuators are not acceptable.
- J. Powering shall be 24VAC, 24VDC, 120VAC, or 230VAC. Feedback signal shall be available to provide a DDC input signal or to drive a second slave or tandem actuator. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if required.
- K. A release button and optional handle on the actuator shall be provided to allow for manual override on non-spring return assemblies.



**PART 3 - EXECUTION**

**3.1 INSTALLATION:**

- A. Install control valves in strict accordance with manufacturer's published instruction manual.
- B. Install control valves with necessary clearance around ball valve assembly.
- C. Install control valves to provide access for periodic maintenance, including removal.
- D. Insulate valve body, not actuator.
- E. Install control valves to prevent condensate forming on valve body to travel into actuator.
- F. Piping installation requirements are specified in other Division 15 Sections.
- G. Electrical power and control wiring and connections are specified in other Division 15 & 16 Sections

**PART 4: COMMISSIONING**

Schedule service of factory trained representative to inspect installation and provide instruction on maintenance to Owner.

**PART V: WARRANTY**

Manufacturer shall guarantee the system as installed to be free from manufacturing defects for a period of 2 years from startup not to exceed 30 months from shipping to job site under normal use.

*END OF SECTION*

**PART I: GENERAL**

SCOPE:

Furnish and install at locations shown on the plans or as specified in schedules, variable frequency drives meeting or exceeding the following specifications.

RELATED WORK:

- a. Section 15750 Pumps
- b. Section 15966 Pump Control
- c. Section 15850 Air Handler Equipment
- d. Division 16

REFERENCES:

- a. UL 508
- b. NEC

**PART II: PRODUCTS**

GENERAL:

- a. Furnish complete variable frequency drives as specified herein for the fans and/or pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 1 enclosure.
- b. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control.
- c. An advanced sine wave approximation and voltage vector control shall be used to allow operation at rated motor shaft output at nominal speed without being de-rated. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life.
- d. The VFD shall include a full-wave diode bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- e. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be Listed by a nationally recognized testing agency such as UL, CUL, ETL, or CSA
- f. The FDA shall have a DC link reactor to minimize power line harmonics. VFD's without a DC link reactor shall provide a 3% impedance line reactor.
- g. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 220% of rated current for up to 1 second while starting.
- h. An automatic energy optimization selection feature shall be provided standard in the drive. This feature shall reduce voltages when lightly loaded and provide a 3% to 10% additional energy savings.
- i. Input and output power circuit switching can be done without interlocks or damage to the VFD.
- j. VFD shall have a Bacnet interface card.

PROTECTIVE FEATURES:

- a. Class 20 I<sup>2</sup>t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications.

- b. Protection against input transients, loss of AC line phase, short circuit, ground fault, over voltage, under voltage, drive over temperature and motor over temperature. The VFD shall display all faults in plain English. Codes are not acceptable.
- c. Protect VFD from sustained power or phase loss. The VFD shall incorporate a 5 second control power loss ride through to eliminate nuisance tripping.
- d. Drive shall catch a rotating motor operating forward or reverse up to full speed.
- e. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

**INTERFACE FEATURES:**

- a. Local/Hand, Stop/Reset and Remote/Auto selector switches shall be provided to start and stop the drive and determine the speed reference.
- b. Digital manual speed control. Potentiometers are not acceptable.
- c. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away.
- d. VFD's up to 300 HP shall use the same control panel.
- e. Displays shall be available in 6 languages including English, Spanish and French.
- f. A quick setup menu with preset parameters shall be provided on the drive.
- g. The drive shall be fitted with an RS 485 serial communications port and be supplied with software to display all monitoring, fault, alarm and status signals The software shall allow parameter changes to be made to the drive settings as well as storage of each controller's operating setup parameters.
- h. Set point control interface (PID control) shall be standard in the unit.
- i. Floating point control interface shall be provided to increase/decrease speed in response to switch closures.
- j. An elapsed time meter and kWh meter shall be provided.
- k. The following displays shall be accessible from the control panel in actual units: Reference Signal Percent, Output Frequency, Output Amps, Motor HP, Motor kW, kW/hr, Output Voltage, No Load Warning, DC Bus Voltage, Drive Temperature (%until trip) and Motor Speed in Engineering units per application (in percent speed, GPM, CFM, ).
- l. Drive will sense the loss of load and signal a no load/broken belt warning or fault.
- m. The VFD shall store in memory the last 8 faults and record all operational data.
- n. Six programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- o. Two programmable relay outputs shall be provided for remote indication of drive status.
- p. Two programmable relay analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include 0-10 V dc, 0-10 mA and 4-20 mA.
- q. One programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, amps and input Kw.
- r. Under fire mode conditions the VFD shall automatically default to a preset speed.
- s. VFD shall receive an Enable/Disable signal from the building Energy Management System as well as an analog speed control signal.

**ADJUSTMENTS:**

- a. VFD shall have an adjustable carrier frequency of 2 of 14 kHz through 60 HP and 2 to 4.5 kHz above 60 HP.
- b. Three variable-torque V/Hz patterns shall be provided with the ability to select a constant torque start pattern for each of them.
- c. Twenty preset speeds shall be provided.
- d. Eight acceleration and eight deceleration ramps shall be provided. The shape of these curves shall be adjustable.
- e. Four current limit settings shall be provided.
- f. If VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, over voltage, current limit, inverter overload and motor overload.

- g. The number of restart attempts shall be selectable from 0 through 10 and the time between attempts shall be adjustable from 0 through 10 seconds.

**BYPASS:**

Provide a manual bypass consisting of a door interlocked main fused disconnect pad lockable in the off position, a built-in motor starter and a four position DRIVE/OFF/LINE/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the drive. In the OFF position, the motor and drive are disconnected. In the LINE position, the motor is operated at full speed from the AC power line and power is disconnected from the drive, so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power. This allows the drive to be given an operational test while continuing to run the motor at full speed in bypass. Customer supplied normally closed dry contact shall be interlocked with the drives safety trip circuitry to stop the motor whether in DRIVE or BYPASS mode in case of an external safety fault.

**SERVICE CONDITIONS:**

- a. Ambient temperature, -10 to 40°C (14 to 104°F).
- b. 0 to 95% relative humidity, non-condensing.
- c. Elevation to 3,300 feet without derating.
- d. AC line voltage variation, -10 to +10% of nominal with full output.
- e. No side clearance shall be required for cooling of wall mount units and all power and control wiring shall be done from the bottom.
- f. Drive shall be capable of operating motor up to 1,000 feet away without derating or field modification.

**QUALITY ASSURANCE:**

- a. To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and the load and speed shall be cycled during the test.
- b. All optional features shall be functionally tested at the factory for proper operation.

**SUBMITTALS:**

- a. Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's FLA rating, certification agency file numbers and catalog information.
- b. The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification are identified; the supplier shall be bound by the specification.

**MANUFACTURERS:**

Variable frequency drives shall be manufactured by Danfoss, ABB, Sq. D, Graham Company, ITT, or other equal approved by Owner. Provide HVAC Series Model VLT or equal.

**PART III: EXECUTION**

**START-UP SERVICE:**

The manufacturer shall provide start-up commissioning of the variable frequency drive and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty

repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for VFD field repair shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Start-up shall include customer operator training at the time of the equipment commissioning.

**WARRANTY:**

The VFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service.

**EXAMINATION:**

- a. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendation shall be verified.
- b. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

*END OF SECTION*

**GENERAL:**

Electrical Contractor shall provide rough-in, junction box, or wiring trough as indicated. All external disconnect switches, motor starters, and any fuses required for equipment furnished under Division 15 shall be provided by the Mechanical contractor and shall be installed by the Electrical Contractor. Coordinate all equipment locations with all other contractors prior to installation of equipment. Consult all Contract drawings which may affect location of equipment or apparatus and make any minor adjustments as required. Electrical Contractor is responsible for all line side and load side wiring for all equipment requiring electrical power. Line side wiring is defined as the wiring from the distribution panel circuit to the point of disconnect (internal or external) for the equipment, whether provided by the contractor or factory installed by the equipment manufacturer. Load side wiring is defined as the wiring from the point of disconnect to all equipment requiring electrical power. All final electrical terminations to the piece of equipment shall be done by the Mechanical contractor.

All control switches for remote equipment shall be provided with on/off indicator lights at the switch.

Ensure that all rotating equipment has a power disconnect available within sight of the equipment, regardless of whether required by the NEC. Coordinate exact locations with Electrical Contractor prior to rough-ins.

The HVAC Contractor shall also provide all control wiring, conduit, equipment interlocks, low voltage device or motor power connections, and similar in accordance with this section or Division 16 of these specifications. Provide all necessary cabinets, panels, junction boxes, interconnecting signal cabling & associated hardware, transformers, relays, engineering support, etc. for a complete and operational system that executes the specified control sequence of operation.

**MOTOR STARTERS, CONTROLLERS AND CONTACTORS:**

Motor controllers and contactors shall be as indicated or specified and shall be furnished under each Section of this Division requiring such controllers unless otherwise indicated to be provided in a Motor Control Center under Division 16. Motor Starters, Controllers, and Contactors shall be furnished by the HVAC Contractor and installed by Electrical Contractor.

Motor controllers shall, unless otherwise specifically noted, be combination magnetic type, with thermal overload relays and heaters in each phase conductor, with operating coils for 120 volts as noted on the drawings or as required. Maximum trip rating of starters for hermetic motors shall be at least 105% of the nameplate full load current of the motor.

Starters shall be provided with build-in selector switches (H-O-A) or pushbutton stations where required. Combination starters shall be provided with sufficient auxiliary contacts or control relays for control sequence as specified, indicated or as required, and with sufficient auxiliary contacts on its circuit breaker or with control relays so that opening the circuit breaker ahead of the starter unit opens all hot control lines within the starters. All starters furnished under this Section shall be mounted in individual NEMA I enclosures, unless otherwise specified or indicated on drawings. Special requirements are specified in the separate Sections of this Division or indicated on the drawings.

Equipment shall be manufactured by Square D to match equipment furnished under Division 16

**ROOM-INSTRUMENT MOUNTING:**

Room instruments shall be mounted so that their switching devices are 54" maximum above the finished floor unless a clear space of 30" wide by 48" long for wheelchair access is not available, mount at 48" AFF to comply with the American Disability Act (ADA).

**CONTROL WIRING:**

Run control wiring in metallic raceway in masonry walls, boiler room and exposed conditions. All other signal cables shall be run on utility platform on wire management bridle hooks provided by this contract. Do not run inside raceway with power conductors. Use copper wire or control cable, #18 minimum (except that digital signaling can be NEC class 2). The contractor shall connect to junction box(s) or other termination points provided by the Electrical Contractor for control power. See Electrical Section of these specifications for materials and installation requirements. All wiring shall be color and number coded.

**RELAYS:**

Indexing relays shall be 24 VAC coils "relay in a box" with pilot light & off/on switch, IDEC or equal. All line side relay wiring shall be 12 AWG and in metallic raceway. Relays shall be installed in NEMA 1 enclosures.

**CONTROL CABINETS:**

Control cabinets shall be provided for mounting of control devices in utility platform and/or boiler room. Cabinet shall be UL listed lockable, code gauge gray painted steel, with knockouts, and hinged door. Enclosure shall be equal to Austin Co. CT series

Provide boiler room cabinet enclosure with swing-down table shelf for use with laptop computer.

**CORRDINATION OF ELECTRICAL POWER REQUIREMENTS:**

Mechanical contractor shall coordinate voltage and amperage requirements for all HVAC equipment with the Electrical Contractor prior to ordering equipment submittals. Make adjustments to equipment voltage or phase requirements as necessary to match electrical power being provided. Make engineer/architect aware of any conflicts or issues.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**ADJUSTMENT AND TRIAL RUNS:**

Upon completion of all work, the Contractor shall operate the plant in the presence of the engineer for the purpose of demonstrating quiet and satisfactory operation, the proper setting of controls, safety and relief valves, and cleanliness of system. Heating and cooling shall be tested separately during periods approaching the design conditions and shall fully demonstrate fulfillment of capacity requirements. Test procedures shall be in accordance with applicable portions of ASME, ASHRAE and other generally recognized test codes as far as field conditions will permit.

**AIR BALANCING & TESTING:**

Air Balancing and System Testing includes (1) balancing air distribution, (2) adjustment of total system to provide design quantities, (3) electrical measurement, (4) verification of performance of all equipment and controls, and (5) sound and vibration measurement. Contractor shall provide all required instrumentation and equipment required to obtain proper measurements. Contractor shall perform final test and balance of selected areas in presence of Engineer. The following procedure is adapted from the 1995 ASHRAE Applications Handbook, Ch. 34: Testing, Adjusting and Balancing, and Associated Air Balance Council:

- (1) All supply and return air-duct dampers are set at full open position. All diffuser and side-wall grilles are set at full open position. Outside-air damper is set at minimum position. All Controls are checked and set for full cooling cycle. Branch liner splitter dampers are set to open position. All extractors and distribution grids are set in wide-open positions.
- (2) Drill all probe holes for static-pressure readings, pitot tube traverse readings, and temperature readings. Check motor electric current supply and rated running amperage of fan motors. Check fan and motor speeds. Check available adjustment tolerance.
- (3) Make first complete air-distribution run throughout entire system, recording first-run statistics. Using pitot tube traverse in all main ducts, branch ducts, and supply and return, proportion all air in required amounts to the various main-duct runs and branch runs. Make second complete air-distribution run throughout entire system for check on proper proportion of air.
- (4) Using pitot tube traverse, set all main-line dampers to deliver proper amount of cfm to all areas. Using pitot tube traverse, set all branch-line dampers to deliver proper amount of cfm to diffusers amount of cfm to diffusers and side-wall supply grilles in each zone. Read cfm at each outlet and adjust to meet requirements. Test and record all items as listed on attached form.

Final air balancing form (3 copies) submitted to Engineer shall be on attached form adapted from the Associated Air Balance Council (AABC) and the National Environmental Balancing Bureau (NEBB).

**HYDRONIC BALANCING & TESTING:**

Hydronic Balancing and System Testing includes (1) bleeding air at all system high points, (2) adjustment of total system to provide design flows, (3) pressure drop measurements & head loss calculations, (4) verification of performance of all pumps, automatic control valves and system controls, and (5) sound and vibration reduction. Contractor shall provide all required instrumentation and equipment required to obtain proper measurements. Contractor shall perform final test and balance of selected equipment in presence of Engineer. The following procedure is adapted from 1995 ASHRAE Applications Handbook, Ch. 34: Testing, Adjusting and Balancing, and the Bell & Gossett Engineering Design Manual:



- (1) Perform air test & balance as specified above.
- (2) Flush & clean system as specified Section 15745. Remove & clean all strainers. Verify correct pump rotation. Pumps shall operate air-free without cavitation. Set automatic fill valves to required pressure.
- (3) Check expansion tanks to verify if system is not water-logged or air-locked. Check all manual air-vents installed at all system high points - bleed all air out of system completely.
- (4) Set all valves at full open position. Close coil bypass valves. Set temperature controls for full flow through all coils.
- (5) Verify correct operation of all automatic control valves. Set operating temperature of chillers to design leaving water temperature.
- (6) Take differential pressure measurements across all pumps & coils. Take power measurements of pump motors in watts (power factor calculated). Use pump manufacturer's published pump curves to determine flow rate.

*END OF SECTION*

**AIR BALANCE REPORT**

Project: \_\_\_\_\_  
 Contractor: \_\_\_\_\_  
 Date: \_\_\_\_\_  
 Air Balanced by: \_\_\_\_\_  
 Instrument Mfr #: \_\_\_\_\_  
 Date Calibrated: \_\_\_\_\_

System No. \_\_\_\_\_  
 CFM: \_\_\_\_\_  
 S.P.: \_\_\_\_\_  
 Fan RPM: \_\_\_\_\_  
 Motor Voltage: \_\_\_\_\_  
 Motor Amperage: \_\_\_\_\_

Location	No.	Model/Size	Effective	Design Values		Field Test		Final Test		% DEV.
			Area	FPM	CFM	FPM	CFM	FPM	CFM	
	1									
	2									
	3									
	4									
	5									
	6									
	7									
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**PROCEDURE/NOTES:**

- (1) Review Specification Section 15980 prior to air test & balance.
- (2) Ensure fan is providing specified air volume within 5%.
- (3) Set all dampers to full open position prior to first field test.
- (4) Identify air distribution device nos. on HVAC as-built drawing.
- (5) Adjust dampers accordingly and recheck entire system as required.
- (6) Acceptable % deviation is +/-10%.

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**EVALUATION:**

Upon completion of all work, the Contractor shall operate the plant in the presence of the engineer for the purpose of demonstrating quiet and satisfactory operation, the proper setting of controls, safety and relief valves, and cleanliness of system. Heating and cooling shall be tested separately during periods approaching the design conditions and shall fully demonstrate fulfillment of capacity requirements. Weather-dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the Contractor shall verify the actual results in the appropriate season.

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, tune the controllers, set the timeclock schedule, and make any necessary control-system corrections to ensure that the systems function as described in the sequence of operation. The Contractor shall permanently record, on system equipment schedule, the final setting of controller proportional, integral and derivative constant settings, setpoint, manual reset setting, maximum and minimum controller output, and ratio and bias settings, in units and terminology specific to the controller.

Test procedures shall be in accordance with applicable portions of ASME, ASHRAE, NEBB and other generally recognized test codes as far as field conditions will permit.

**CLEANING:**

All surfaces on metal, pipe, insulation covered surfaces, and other equipment furnished and installed under this section of the specifications shall be thoroughly cleaned of grease, scale, dirt, and other foreign materials. Prior to final inspection, all equipment having factory finishes shall be thoroughly cleaned inside and outside. All damaged surfaces shall be replaced or refinished by Contractor, with paint same as original manufacturer. Engineer shall determine whether the damaged surface is to be replaced or painted.

**EQUIPMENT IDENTIFICATION:**

Provide black-on-white laminated plastic name plates for each AHU & FC equipment unless indicated otherwise on the drawings. The name plate shall be engraved to indicate the equipment controlled or identified. Name plates shall be securely fastened to equipment using two screws.

**MAINTENANCE AND OPERATING MANUALS:**

Upon completion, the MC shall turn over to the Architect three (3) sets of complete Operation and Maintenance Manual and parts list for all mechanical equipment used on the job. Manuals shall include submittal data, manufacturer's recommended maintenance, warranties, and name, address, and phone numbers, both Contractor and of suppliers of equipment.

The Operation and Maintenance Manual shall include in addition to manufacturer's operation and maintenance guides and parts list, a maintenance schedule indicating recommended frequency of service, a blank service repair log for recording date, description of maintenance, and parts purchased, and an air filter replacement schedule indicating size and quantity for each HVAC unit.

**INSTRUCTION & TRAINING:**

Upon completion of the work, and at a time designated by the Architect, with no less than 10 days prior notice, a competent employee of the Contractor shall be provided for a period of not less than one (1) day

to instruct a representative of the Owner in the operation and maintenance of the equipment. Systems requiring manufacturer's representative as specified elsewhere shall be scheduled in same manner. Instruction periods shall be as designated by the Owner and shall not necessarily be consecutive.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SCOPE OF WORK:**

The scope of work consists of the furnishing and installing of complete electrical systems including miscellaneous systems. The Electrical Contractor (hereafter referred to as "the Contractor", or Electrical Contractor) shall provide all supervision, labor, materials, equipment, machinery, and any and all other items necessary to complete the systems. The Contractor shall note that all items of equipment are specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on the drawings and as required for complete systems.

It is the intention of the Specifications and Drawings to call for finished work, tested and ready for operation.

Any apparatus, appliance, material, or work not shown on the drawings but mentioned in the specifications, or vice versa, or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered, and installed by the Contractor without additional expenses to the Owner.

Minor details not usually shown or specified, but necessary for proper installation and operation, shall be included in the Contractor's estimate, the same as if herein specified or shown.

With submission of bid, the Contractor shall give written notice to the Architect of any materials or apparatus believed inadequate or unsuitable, in violation of laws, ordinances, rules, and any necessary items or work omitted. In the absence of such written notice, it is mutually agreed that the Contractor has included the cost of all required items in his proposal, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensation.

NOTICE TO BIDDERS, INSTRUCTIONS TO BIDDERS, SUPPLEMENTARY INSTRUCTIONS, GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, SPECIAL CONDITIONS, GENERAL REQUIREMENTS bound in the front of this document are included as a part of the specifications for this work.

**ELECTRICAL DRAWINGS AND SPECIFICATIONS:**

The electrical drawings are diagrammatic and indicate the general arrangement of fixtures, equipment, and work included in the contract. Consult the architectural, structural, plumbing, fire alarm, integrated communications, and mechanical drawings and details for exact locations and dimensions of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.

The Contractor shall follow drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Architect shall be notified before proceeding with installation. If directed by the Architect, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.

The plans and these specifications are intended to describe, imply and convey the materials and equipment as well as necessary labor, required for the installation as outlined in the paragraph entitled "Scope of Work". Any omissions from either the drawings or these specifications are unintentional, and it shall be the responsibility of this Contractor to call to the attention of the Architect or Engineer any pertinent omissions before submission of a bid. The drawings which accompany these specifications are not intended to show in complete detail every fitting which may be required; however wherever reasonable implied by the nature

of the work, any such material or equipment shall be installed by this Contractor as a part of his contract price. In no case will any extra charge be allowed unless authorized in writing by the Architect or Engineer.

The Contractor shall arrange with the General Contractor for required concrete and masonry chases, openings, and sub-bases so as not to delay progress of work. Work shall be installed sufficiently in advance of other construction to conceal piping and to permit work to be built in where required.

It shall be understood and agreed by all parties that where the words "Furnish", "Install", and / or "Provide" appear, the following definitions apply:

Furnish - to supply or give.

Install - to place, establish or fix in position.

Provide - to furnish and install as defined above.

#### CODES, PERMITS, AND FEES:

The Contractor shall give all necessary notices, including electric and telephone utilities, obtain all permits, and pay all government taxes, fees, and other costs, including utility connections or extensions in connection with his work file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction at each phase of construction as required; obtain all required certificates of inspection for his work and deliver same to the Architect before request for acceptance and final payment for the work.

The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, drawings (in addition to contract drawing and documents) in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not shown on drawings and / or specified.

All work and materials under this section shall be in strict compliance with more stringent requirements of the North Carolina State Building Code, including the National Electrical Code, NFPA 101-Life Safety Code, Regulations of the State Fire Marshall, UL Directory of Electrical Construction Materials, and requirements of the local utility company.

#### VERIFICATION OF DIMENSIONS, DETAILS, EXISTING FIELD CONDITIONS:

The Contractor shall visit the premises prior to bidding, and thoroughly familiarize himself with all details of the work, working conditions, verify dimensions in the field, provide advice of any discrepancy, and submit shop drawings of any changes he proposes to make in quadruplicate for approval before starting any work. The Contractor shall install all equipment in a manner to avoid building interference.

#### COORDINATION WITH EQUIPMENT PROVIDED BY OTHERS:

Electrical contractor shall coordinate voltage, phase and amperage requirements for all Plumbing, HVAC, and Kitchen equipment with the sub-contractor providing the equipment prior to ordering electrical gear submittals. Make adjustments to panels, feeders, and breakers as necessary to feed actual equipment being provided. Make engineer/architect aware of any conflicts or issues.

#### ACCEPTABLE MANUFACTURERS:

Acceptable manufacturers, as specified in the Contract Documents, implies that the specified manufacturer may produce acceptable products equal in quality of materials and performance to such item specified. The Contractor will be required to provide products meeting or exceeding the "Standard of Quality and Performance" as dictated by the product selection noted. However, any changes which result (from substitution of other manufacturers) in the electrical work or work of other Contractors, shall be paid for by the Contractor.

**SHOP DRAWINGS:**

The Contractor shall submit five (5) copies of the shop drawings to the Architect for approval within thirty (30) days after the award of the general contract. If such a schedule cannot be met, the Contractor may request in writing for an extension of time to the Architect. If the Contractor does not submit shop drawings in the prescribed time, the Architect has the right to select the equipment.

Provide manufacturer's cuts of items to be provided under this Contract. Included, but not limited to these items, are any of the following which may be required in this Contract: Fixtures, switches, outlet boxes, device plates, panelboards, transformers, conductors, pull boxes, wiring troughs, circuit breakers, disconnect switches, emergency fixtures, receptacles, etc.

The shop drawings shall be neatly bound in five (5) sets and submitted to the Architect with a letter of transmittal. The letter of transmittal shall list each item submitted along with the manufacturer's name.

Approval rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are approved, said approval does not mean that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the contract drawings and specifications.

**COORDINATION WITH OTHER TRADES:**

Coordinate all work required under this section with work of other sections of the specifications to avoid interference. Bidders are cautioned to check their equipment against space available as indicated on drawings and shall make sure that proposed equipment can be accommodated. If interferences occur, Contractor shall bring them to attention in writing, prior to signing of contract; or, Contractor shall at his own expense provide proper materials, equipment, and labor to correct any damage due to defects in his work caused by such interference.

**INSPECTION AND CERTIFICATES:**

On the completion of the entire installation, the approval of the Architect and Owner shall be secured, covering the installation throughout. The Contractor shall obtain and pay for Certificate of Approval from the public authorities having jurisdiction. A final inspection certificate shall be submitted to the Architect prior to final payment. Any and all costs incurred for fees shall be paid by the Contractor.

**EQUIVALENTS:**

When material or equipment is mentioned by name, it shall form the basis of the Contract. When approved by the Architect in writing, other material and equipment may be used in place of those specified, but written application for such substitutions shall be made to the Architect as described in the Bidding Documents. The difference in cost of substitute material or equipment shall be given when making such request. Approval of substitute is, of course, contingent on same meeting specified requirements and being of such design and dimensions as to comply with space requirements.

**EXCAVATING AND BACKFILLING FOR ELECTRICAL WORK:** Refer to Sections 02202 & 02220.

**CUTTING AND PATCHING:**

On new work, the Electrical Contractor shall furnish sketches to the General Contractor showing the locations and sizes of all openings and chases, and furnish and locate all sleeves and inserts required for the installation of the electrical work before the walls, floors, and roof are built. The Electrical Contractor shall be responsible for the cost of cutting and patching where any electrical items were not installed or where incorrectly sized or located. The Contractor shall do all drilling required for the installation of his hangers. See also Section 01050.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**CONDUIT SYSTEM:**

Furnish and install all conduits, or other raceways, fittings, boxes, and other component parts specified or required for completion and proper operation of the power distribution, fire alarm, data, security and other low voltage systems shown on the drawings. See also Fire Alarm, IC and Security drawings and coordinate closely with all of the Low Voltage System Sub-Contractors for their requirements during construction. All Fire Alarm conduit with associated junction boxes and covers shall be red in color.

Other than as noted above, conduit shall be sized in accordance with the current NEC. All conduit shall be neatly installed parallel to, or at right angles to beams, walls and floors of the building in a neat and workmanlike manner. All bends shall be made with standard conduit elbows or conduit bent to not less than the same radius as that of a standard conduit elbow. Conduits shall be supported at intervals not greater than 8' and within 3' of any bend, cabinet, outlet or junction box. Conduits shall be supported by approved pipe straps or clamps, secured by means of toggle bolts on hollow masonry, expansion shields and machine screws or standard pre-set inserts on concrete or solid masonry, machine screws or bolts on metal surfaces, and wood screws on wood construction.

Conduit 3/4" (minimum) and larger shall be electrical metallic tubing (EMT). EMT shall be cold-rolled steel tubing with a coating on the outside and protected on the inside by a zinc, enamel, or equivalent corrosion-resistant coating and conforming to the requirements of ANSI C 80.3-1966 or later edition. EMT may be installed in dry construction in furred spaces, in partitions other than concrete and solid plaster, or for exposed work except on mechanical structures or supports, or in refrigerated areas. EMT shall not be installed where: it will be subject to physical damage; where it will be installed nearer than 4' from finished floor in exposed areas; where it will be subject to severe corrosive influence; where the trade size is larger than 2"; where it will be installed in masonry walls; or where tubing, elbows, couplings, and fittings would be in concrete or in direct contact with the earth. Electric metallic tubing fittings shall be all plated steel hexagonal threaded compression type, with insulated throats. No pot metal, set screw, or indenter fittings shall be used. PVC conduit shall be used in masonry wall construction. Contractor shall transition to EMT or rigid conduit at the top of masonry walls. PVC conduit shall not be used in stud walls.

Connections to lighting fixtures will be permitted with flexible steel conduit strapped every 6'-0", with UL listed AC type cables, used in strict accordance with current NEC Article 333. Armored Cable assembly shall encase conductors in a continuous length of galvanized cold rolled steel strip, spirally wound with adjacent strips locked to turn all edges inward. The ends shall be terminated with fiber bushings to protect conductors from sharp edges. Fittings shall be the insulated throat type, T & B 3100 series or equivalent.

All underground conduit shall be UL Listed Schedule 40 PVC conforming to Article 347 of the current NEC, or rigid galvanized steel. At the Contractor's option, this installation may consist of rigid steel conduit with PVC coating, minimum of 15 mils of PVC. Where schedule 40 PVC is installed under floor slabs, the elbows required to turn the raceway up into cabinets, equipment, etc., shall be of rigid steel. A copper ground wire shall be installed in all PVC conduits. PVC conduit shall not be used above the floor slab, unless roughed-in masonry.

All exposed conduit to 5'- 0" above finish floor shall be rigid galvanized steel or IMC conduit. Liquid-tight flexible steel conduit with an extruded PVC jacket shall be used for connections to exterior motors and compressors. Liquid-tight flexible conduit fittings shall be insulated throat type, Appleton STB type or equal.

All permanent conduit stub-outs shall be sealed with galvanized standard water pipe caps immediately after installation. All conduits crossing expansion joints shall have approved type expansion fittings as manufactured by Crouse Hinds, Killark or Appleton. Fittings shall be of type to ensure ground continuity. Provide a 240 lb. tensile strength poly pull-wire in all empty conduits.



**SURFACE MOUNTED RACEWAY:**

Two piece metal surface mounted raceway shall be used in all cases where it is not possible or desirable to run conduit concealed in the wall unless specifically noted otherwise on the plans. Provide Wiremold 3000 Series or equal. Provide large divided two channel raceway (4000 Series) in locations where power and low voltage wiring are to be routed in the same raceway.

**CABLE TRAY:**

Cable trays shall be aluminum ladder style trays suspended from structural elements above. Locate in the platforms, IDF, MDF and other areas as indicated on plans. Changes in direction shall be accomplished by utilizing standard radiused 90 degree and 45 degree fittings from the same manufacturer. Ladder tray system shall be 18" wide minimum. Provide B-line or equal by Monosystems or TRG.

**OUTLETS AND PULL BOXES:**

All boxes shall be UL labeled or listed by an approved agency. At each location where required, an outlet box of a type to suit the intended use shall be installed. Boxes shall be fastened to building structure in an approved manner. Flush outlet, junction and pull boxes shall be pressed galvanized or sheradized steel, either square or octagonal with knockouts on tops and sides, and fitted with plaster covers where necessary to set flush with the finished surface. For use in hollow-core masonry walls, switch boxes shall be of sufficient depth to permit conduit to rise in the core with minimum cutting of block. Provide plaster rings or box extensions for flush devices with finish surface. Boxes for unplastered masonry walls shall be masonry type with device mounting ears on the interior of the box.

Convenience outlet boxes shall be generally mounted approximately 18" above floor, 48" above floor in mechanical equipment rooms and shop type areas, and 4" above counter backsplash, unless otherwise noted. Convenience outlets for drinking fountains shall be installed behind fountain enclosure so as not to be visible; coordinate with Plumbing Contractor.

Lighting switch outlet boxes shall be 4' above floor, unless noted or required otherwise. Where switches occur in 4' high tile walls, they shall be lowered by 6 inches.

Pull boxes shall be used as required in long runs of conduit to facilitate pulling of wires. All interior pull boxes shall be constructed of code gauge galvanized sheet metal, and not less than the minimum size recommended by the NEC. Boxes shall be furnished with screw-fastened covers. When several feeders pass through a common pull box they shall be tagged to indicate clearly their electrical characteristics, circuit number, and panel designation. Wire markers shall be as manufactured by W. H. Brady Co., or equal. In no case shall a pull box be installed in an inaccessible location. Boxes shall be provided with fixed or removable steel barriers for each circuit where two or more feeders pass through the box. In case of banked conduit runs consisting of more than two horizontal rows of conduits, where barriers would be impracticable, the cables for each conduit shall be tied together with heavy waxed twine and wrapped with one wrap of heavy grade tape.

Where two or more outlets are to be installed in one location, they shall be installed in gang boxes suitable for the intended purpose.

Outlet boxes for outdoor use, and for exposed use where not covered by fixture canopies, shall be cast metal suitable for the intended purpose, having integral threaded hubs, and of the weatherproof type with gasket. Provide special outlet boxes where indicated.

All junction boxes shall be marked with panel and circuit number which it contains.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**CONDUCTORS FOR 600 VOLTS OR LESS:**

All conductors shall be copper with a minimum conductivity of 98% and shall be delivered to the job site in their original packages, marked or tagged as follows : UL label , size, type, and insulation of the wire; name of manufacturer and trade name of the conductor: and date of manufacture. All conductors shall be insulated for 600 volts unless otherwise indicated. Furnish and install all conductors specified or required for completion and proper operation of the various systems shown on the drawings.

Conductors shall be 600 volt type THW or THWN. Branch circuit conductor shall not be smaller than No. 12 AWG, except where specifically noted otherwise. Home runs originating more than 80' at 120 volts from panel location shall be No. 10 AWG minimum size. Wires No. 10 AWG and smaller shall be solid; wires No. 8 AWG and larger shall be stranded. Where branch circuits are fed through fluorescent fixture channels, use code grade type THHN or XHHW. All MC cables where permitted shall include a separate copper ground conductor sized per phase conductors.

Provisions of Section 210-5, Color Code, NEC, shall be strictly complied with. Color coding shall include feeders and mains and be consistent throughout entire system. For 120/208 volt systems, use black, red, and blue for phases A, B, & C respectively. For 277/480 volt systems, use brown, orange, and yellow for phases A, B, & C respectively.

All conductors in vertical raceways shall be properly supported at intervals not greater than those specified in Section 300-19 of NEC.

All wire and cable except as specifically stated otherwise, shall be of one of the following makes: Anaconda Wire and Cable Co., General Cable Corp., General Electric Co., or Okonite Co.

**LOW VOLTAGE DATA & TWISTED PAIR CABLES:**

Data – See Division 17 Specifications for data cable requirements.

Twisted Pair (Shielded or Unshielded) – Conductors shall be insulated copper. Coordinate requirements for type, size and quantity of conductors in the shielded or unshielded cables with the equipment being served by the twisted cables (Fire Alarm Equipment/Devices, Intercom Devices, Speakers, Amps, phones, etc.).

Any low voltage cable that is not installed in a conduit or raceway shall be run concealed above ceilings or in the mechanical platforms. They must be properly supported with j-hooks or cable management devices that clip onto ACT support wires that are specifically designed for the purpose of supporting the cables. Zip ties are NOT acceptable as a method of securing/supporting cables. Zip ties may be used to bundle cables for easier management and neatness of installation.

**JOINTS AND CONNECTIONS:**

The Engineer reserves the right to inspect any and all joints made in wiring. If they are taped prior to being inspected, the tape shall be removed as ordered from any joint or joints for inspection. After inspection and correction of any fault found, the Contractor shall properly retape the joints.

Conductors shall be continuous without joints or splices in runs between outlet boxes. All splices shall be made at boxes only. Where stranded conductors are to be connected to any apparatus, bus work, switches or fuse blocks, they shall be connected by suitable mechanical solderless type lugs or spades. All lugs shall be

permanently bolted in such position as to give maximum contact surface available. Where multiple circuits are run from same switch or panel, individual lugs for each conductor shall be used. Feeder taps in junction boxes or panel gutter shall be made with insulated cover panel guttertaps. Feeder conductors shall not be spliced, feeder conductors shall be continuous for the length of run.

Solid conductors, namely those sized #10 and #12 AWG copper, shall be spliced by using Ideal "wire-nuts", 3M Co. "Scotchlok", or T & B "Piggy" connectors for branch circuit splices in junction boxes and light fixtures, except recessed fixtures as noted above. "Sta-Kon" or other other permanent type crimp connectors shall not be used.

Stranded conductors, namely #8 AWG copper and larger, shall be spliced by approved mechanical connectors plus gum tape, plus friction or plastic tape. Solderless mechanical connectors, for splices and taps, provided with UL approved insulating covers, may be used instead of mechanical connectors plus tape.

#### DEVICE PLATES:

A device plate shall be provided for each outlet to suit the device installed. All plates shall be no. 302 stainless steel construction. All plates shall be "jumbo" size.

Device plates shall be of the one piece type, of suitable shape for the devices to be covered. The use of sectional device plates will not be permitted. Plates having a .375" bushed hole in the center shall be installed on all wall mounted outlets for telephones.

Devices and/or plates installed prior to painting shall be properly taped and shall be cleaned after painting, if necessary. Blank plates shall be installed on all unused outlets.

Plates shall be manufactured by Pass & Seymour, Bryant, or Hubbell. Provide sample of plates to Architect for approval.

#### RECEPTACLES:

Duplex convenience outlets for general use shall be rated 20 amperes, 125 volts, duplex, for standard parallel blade three-wire grounded type caps, Hubbell No. 5362-I (ivory), Leviton, Pass & Seymour or Arrow-Hart or approved equal. Color to be selected by Architect. Where outlets are installed vertically, ground plug position shall be on top and on right side where outlets are installed horizontally.

#### SPECIAL USE RECEPTACLES:

Provide special receptacles including receptacles with ground fault circuit interrupter protection, where needed, as required by equipment. Provide MOV-based transient voltage surge suppression devices (SS), where shown on plan. Tamper-resistant receptacles (TP) shall prevent insertion of objects other than a properly rated 2 or 3 wire plug using "floating" shutters. Equal devices by Hubbell, Leviton, Pass & Seymour or Arrow-Hart are considered acceptable.

#### WALL SWITCHES:

Wall switches shall be installed as shown on the drawings and shall be connected to provide control of the outlets indicated. Switches shall be rated at 20 amperes for 120 volts or 277 volts lighting circuits. Hubbell No. 1221 (or 1221-1), for single pole; Hubbell Catalog No. 1223 (or 1223-1) for 3-way; Hubbell Catalog No. 1224 (or 1224-1) for 4-way. Weather-proof switches shall be Hubbell No. 1781 single pole or Hubbell No. 1783 3-way. Provide sample of switches to Engineer for approval. Color of switches to be selected by Architect.

Automatic light switches shall have passive infra-red occupancy switch with light sensor to prevent light from switching on when daylight is above pre-set level. Switch shall be UL listed, have adjustable time delay of 30

seconds to 30 minutes, auto/off control, and minimum coverage of 900 square feet, Automatic light switch shall be UNENCO model no. D-IS.

Provide special purpose switches where noted on the drawings, or elsewhere. Equal devices by Pass & Seymour or Arrow-Hart are considered acceptable.

For wall switches indicated as dimmers on LED lighting, coordinate the exact 0-10 volt dimmer that is compatible with LED driver at 277V for the specific fixtures provided. Install the correct size wall box to accommodate the specific dimmer to be installed.

*END OF SECTION*

**SERVICE EQUIPMENT AND POWER DISTRIBUTION:**

Furnish, install and completely connect the circuit breaker type service, panelboard and distribution equipment as indicated. All construction shall meet applicable standards of ANSI, IEEE, and NEMA, and all equipment shall bear UL label insofar as it is available. Equipment shall be Square D QED, I-Line or QMB; equipment manufactured by Cutler-Hammer (Eaton) , General Electric, or ITE Siemens will be considered equal.

Provide a copper bus interior with an insulated neutral in the Main Distribution Panel. This neutral bus shall be the source for all insulated neutral conductors of the system. Jumpers shall be installed to connect the insulated neutral bus to the uninsulated grounding bus. The uninsulated grounding bus shall be the source of grounds for all grounding and bonding (not neutrals) of equipment. Equipment UL listed for use as a Service Entrance shall have the Neutral and Ground bars bonded together per Current NEC requirements.

Electrical contractor is responsible for providing all transformer and equipment data to gear supplier as necessary for the supplier to evaluate and coordinate any circuit breaker settings to ensure that downstream breakers trip prior to any upstream breakers.

**LIGHTING AND POWER PANELBOARDS:**

Panelboards shall be of the thermal-magnetic circuit-breaker type and shall consist of an assembly of single, double, and triple-pole breakers. Each circuit-breaker shall be bolted-in, removable without disturbing the adjacent units and shall have trip ratings as indicated. All multipole breakers shall be common trip. Ground fault circuit breakers shall be used as indicated on the drawings.

Each panelboard shall be installed in an appropriate cabinet of sufficient size with top 6'- 0" above finish floor and shall conform to the requirements of UL standard for cabinets and boxes. Standard cabinets with surface or flush type trim and door shall be used, as required. Cabinets shall have a minimum width of 20" unless noted otherwise. A neutral bar shall be provided in each panel with a terminal for each breaker. Grounding lugs shall be provided.

Cabinet shall be made of spot welded galvanized sheet steel not less than N.E.C. gauge with hinged door and trim of the same material. When closed, the door shall fit accurately in the opening provided and present a flush finish with the trim. The door shall be equipped with a key operated lock. Furnish one key with each lock. All door locks shall be keyed alike. Knockouts in cabinets are not acceptable. Cabinets shall be finished with manufacturer's standard painted finish.

On the inside of each door, a typewritten directory identifying each circuit shall be mounted in a suitable protective enclosure. Panelboards shall have laminated plastic designations on inside corresponding to feeder and drawing identifications.

Panelboards shall be Square D I-Line or NQOD Series or equal by Cutler-Hammer, General Electric, or Siemens.

**SHUNT TRIP PROTECTION:**

All electrical equipment located under a kitchen hood with a fire suppression system shall be protected by a shunt trip device that is interlocked with the suppression system. Upon activation of the suppression system the shunt device shall trip and disconnect power for the equipment under the hood. This may be done via individual shunt trip breakers or a single main breaker that is shunted upon activation of the suppression system. If a main shunt breaker is utilized no circuits should be fed from the respective distribution panel other than the circuits for the equipment under the hood. Elevator feeder circuits shall also be protected by a shut trip device if the elevator shaft and/or the elevator equipment room are protected by a fire suppression system. Coordinate with the General Contractor for final plans from the Sprinkler Design-Build Contractor.

**SURGE PROTECTION:**

Furnish and install transient voltage surge suppressor (TVSS) units where indicated on the drawing risers as 'SP' to protect AC electrical circuits from the detrimental effects of lightning, utility switching transients, AC motor transients, and other internal generated transients. TVSS shall comply with UL 1449, have a Category C pulse life for all protection modes (L-N, L-G or L-L where applicable), shall operate bio-directionally, and shall have a maximum single pulse current capacity of 50 KA per mode in accordance with NEMA LS1-1992. Acceptable manufacturers include Leibert, Current Technology, LEA, and United Power. Provide complete shop drawing submittal including installation instructions, dimensional drawings, clamp voltage data, and 3rd party data confirming single pulse current capacity rating. Provide on-site manufacturer's testing and start-up.

**SAFETY DISCONNECT SWITCHES:**

Disconnect switches shall be horsepower rated, installed where indicated and / or required by the NEC. Switches, except where shown as beined by other sections shall be furnished under this Section. Switches shall be heavy duty, fused unless otherwise noted, sized as shown, quick-make, quick-break, NEMA type "ND" with NEMA 1 enclosure, type HD, Square D. Switches to be installed outdoors shall be NEMA type 3R, with raintight conduit hubs. All switches shall be capable of being locked in the "off" position. Fuses shall be one-time, non-renewable types, dual-element, time-delay, Bussman or equal as required for application.

**MOTOR STARTERS:**

Motor controllers shall, unless otherwise specifically noted, be combination magnetic type, with thermal overload relays and heaters in each phase conductor, with operating coils for 120 volts as noted on the drawings or as required. Maximum trip rating of starters for hermetic motors shall be at least 105% of the nameplate full load current of the motor.

Starters shall be provided with build-in selector switches (H-O-A) or pushbutton stations where required. Combination starters shall be provided with sufficient auxiliary contacts or control relays for control sequence as specified, indicated or as required, and with sufficient auxiliary contacts on its circuit breaker or with control relays so that opening the circuit breaker ahead of the starter unit opens all hot control lines within the starters. All starters furnished under this Section shall be mounted in individual NEMA I enclosures, unless otherwise specified or indicated on drawings. Special requirements are specified in the separate Sections of this Division or indicated on the drawings.

**LIGHTING CONTACTORS:**

Each lighting contactor shall have heavy-duty ballast load rated contacts. Each contactor shall have mechanically held contacts, and silver cadmium oxide double break contacts. Contacts shall be field convertible with normally open and normally closed indicators. Each contactor shall be UL listed and CSA certified. All new lighting contactors for each new building shall be housed in a properly sized NEMA-1 enclosure with fully hinged and lockable door.

**FIRE ALARM & HVAC CONTROLS:**

Electrical contractor is responsible for all conduit and wiring required to power any fire alarm control or booster panels, magnetic door holders, and the HVAC Building Automation Controls system cabinets. There shall be at least (2) Fire Alarm and (2) HVAC control system circuits per wing of the school. Coordinate exact location and quantity of cabinets with Fire Alarm and Mechanical's Controls Sub-Contractor. Termination to Fire Alarm and HVAC controllers and to HVAC equipment shall be by controls contractor. Electrician shall use 1P-20A circuits designated as Fire Alarm or HVAC Controls on panel schedules or the closest available spare 1P-20A (120V) breakers for powering the controls system. Notify Engineer if circuits were not indicated and update panel directories on Record Drawings.

**ELECTRONIC DOOR ACCESS CONTROL HARDWARE:**

Electrical contractor is responsible for all conduit and wiring required to power any and all electronic door access control hardware that is part of the Door Access Control system. Electrical contractor shall coordinate the exact quantities and locations of the Electronic Door Access Control equipment with the Door Hardware Schedules located in the Architectural Drawings and with the Door Access Control section of the Door Hardware specification. Electrical Contractor shall use 1P-20A circuits designated as Door Access Controls on electrical panel schedules or the closest available 1P-20A (120V) breakers for powering the Door Access Control equipment. Notify Engineer if circuits were not indicated and update panel directories on Record Drawings.

**GROUNDING:**

Provide a bare stranded continuous copper grounded conductor, size as indicated, from the service equipment grounding bus to the cold-water service main where it enters the building ahead of main valve on water pipe main. Also, provide a driven ground per NEC 250-81 (a). Provide all necessary grounding clamps and full-size jumpers around all valves, meters, and similar fittings between point of connection and street main. The main grounding conductor shall be connected to the neutral conductor at one location only, within and on the low voltage side of the main transformer and more specifically the equipment grounding bus associated with the main insulated neutral bus in the MDP. The insulated neutral bus must be insulated and serve to provide the neutral source for all the insulated neutral conductors of the system. Jumpers shall be installed to connect the insulated neutral bus to the uninsulated grounding bus and all grounding and bonding of equipment (not neutrals) shall be attached to the uninsulated grounding bus.

System and equipment grounds shall be checked for proper value of resistance using the Megger ground tester in accordance with the method prescribed by the manufacturer of the instruments. Resistance of ground shall not be in excess of 25 ohms, measured to include the grounding cable. The Contractor shall report the results of these tests to the Engineer in writing. If the resistance cannot be reduced to the value prescribed above, further instructions will be given the Contractor.

All equipment connected under this section shall be grounded and shall conform with the more stringent requirements of the NEC, National Electrical Safety Code, the N. C. State Building Code, or this specification.

Panels, junction boxes, safety switches, disconnect switches, contactors, starters, motors, dry transformers, bus duct and other equipment shall be bonded to the conduit system with a grounding conductor by means of grounding locknuts and bushings as required hereinafter, except where conduit terminates in threaded hub or fittings. All joints or terminations shall be made with standard tapered pipe threads drawn tight to preserve electrical continuity.

Provide grounding bushings and copper jumpers across all concentric or eccentric knockouts and on all conduits larger than 1". Elsewhere, double-lock-nuts with plastic or fiber bushings, or a single lock-nut and malleable bushing may be used. If Contractor selects to use a single locknut and malleable bushing, care shall be taken that the full number of threads project through to permit the bushing to pull tight against the ends of the conduit, after which the lock-nut shall be made up sufficiently tight to draw the bushing into firm electrical contact with the box.

Where flexible conduits are used, provide grounding conductor within flexible conduit to ensure continuity of ground. Minimum size of jumper around flex shall be No. 10.

**EQUIPMENT IDENTIFICATION:**

Provide black-on-white laminated plastic name plates for each switch or circuit breaker on service equipment, disconnect switches, terminal cabinets, panelboards and wiring troughs. The name plate shall be engraved to indicate the equipment controlled or identified. Name plates shall be securely fastened to equipment using two screws.

**CONNECTIONS TO EQUIPMENT:**

Electrical Contractor shall provide rough-in, junction box, or wiring trough as indicated. Electrical Contractor shall provide and install disconnect switches and motor starters for equipment provided under Division 16. All external disconnect switches, motor starters, and any fuses required for equipment furnished under Division 15 shall be provided by the Div 15 contractor and installed by the Electrical Contractor. Coordinate all equipment locations with all other contractors prior to installation of electrical equipment. Consult all Contract drawings which may affect location of equipment or apparatus furnished by others and make any minor adjustments as required. Electrical Contractor is responsible for all line side and load side wiring for all equipment requiring electrical power. Line side wiring is defined as the wiring from the distribution panel circuit to the point of disconnect (internal or external) for the equipment, whether provided by the contractor or factory installed by the equipment manufacturer. Load side wiring is defined as the wiring from the point of disconnect to all equipment requiring electrical power. All final electrical terminations to the piece of equipment shall be done by the contractor providing the equipment.

Electrical Contractor must closely coordinate with the equipment supplier regarding Voltage, H. P., F. L. A., outlet mounting heights, connection cord plug-receptacle electrode configurations and other special wiring requirements.

Electrical Contractor is responsible for coordinating quantity and location of all sprinkler system devices with sprinkler contractor.

Electrical Contractor shall review the Architectural, Civil, Plumbing, Mechanical, Fire Alarm and IC plans to provide branch circuits and final connections to powered equipment furnished by others for complete and operational equipment. This is a sample list and may not represent all connections required:

- 1) MDF & IDF equipment racks
- 2) Data Equipment Racks not in MDF or IDF rooms.
- 3) HVAC Controls Equipment
- 4) Heat trace for freeze protection (See Mechanical Plans)
- 5) Controlled Access electrified security doors (See Door Hardware Schedule)
- 6) Sprinkler controls/panels
- 7) Projectors and associated screens
- 8) Hand Dryers (See Architectural plans and elevations)
- 9) Electric Water Heaters & Associated Recirculation Pumps (Refer to Plumbing Plans)
- 10) Dishwashers (Kitchen and/or Science Prep)
- 11) Clothes Washers and Dryers
- 12) Art Room Kilns and associated fans
- 13) Fire Pumps (Main and Jockey)
- 14) Fire Alarm Control Panels and Booster Panels (See FA Contractor Shop Drawings)
- 15) Fire Shutters (See Architectural Plans & Specifications)
- 16) Overhead Doors
- 17) Motorized Basketball Goals and/or Gym Divider Curtains
- 18) Scoreboards and Shot Clocks
- 19) Motorized Bleachers
- 20) PA Systems and associated amplifiers (Gym, Café, Auditoriums and MP Rooms)
- 21) Powered Hotboxes (See Civil Site Plan for exact locations)

*END OF SECTION*



**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**GENERAL:**

Dry-type transformers shall be air cooled, 480V Delta Primary, 208/120V WYE secondary with 2-2 1/2 taps above and 2-2 1/2 taps below, 60 Hz. Noise level shall not exceed 45 dB for transformers under 50kVA, and 50 dB from 50kVA to 225kVA Transformers shall not exceed 115°C rise above 40°C ambient. All insulation shall meet NEMA ST20 Standard. Neutral shall be full sized, core of transformer shall be grounded. Enclosure shall be heavy gauge steel with ventilating openings designed to prevent accidental to live parts in accordance with UL, NEMA and NEC standards.

**QUALITY ASSURANCE:**

UL Compliance: Comply with applicable requirements of ANSI/UL 506; "Safety Standard for Specialty Transformers". Provide dry type transformers and components which are UL listed and labeled.

NEC Compliance: Comply with NEC as applicable to installation and construction of electrical dry type transformers.

NEMA Compliance: Comply with requirements of NEMA Std Pub/No.'s ST 20; "Dry-Type Transformers for General Applications", TR 1, and TR 27.

**SUBMITTALS:**

Product Data: Submit manufacturer's technical product data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100% and 80% power factor, no-load and full-load losses in watts, % impedance at 75°C, hot-spot and average temperature rise above 40°C ambient temperature, sound level in decibels, and standard published data.

Shop Drawings: Submit manufacturer's drawings indicating dimensions, and weight loadings.

**EXECUTION:**

Install transformers where indicated, complying with manufacturer's instruction, applicable requirements of NEC, NESC, NEMA, ANSI and IEEE standards, and in accordance with recognized industry practices to ensure that products fulfill requirements.

Coordinate transformer installation work with electrical raceway and wire/cable work, as necessary for proper interface.

Connect dry type transformers to electrical wiring system with flexible conduit; comply with requirements of other Division 16 sections.

Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirement are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A and B.

Grounding: Provide equipment grounding connections for transformers as required by N.E.C. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

Testing: Prior to energization of transformer, check all accessible connections for compliance with manufacturer's torque tightening specifications.

Prior to energization of transformer, check circuitry for electrical continuity, and for short-circuits.

Upon completion of installation of transformer, energize primary circuitry at rated voltage and frequency from normal power source, and test transformer, including, but not limited to, audible sound levels, to demonstrate compliance with requirements.

Equipment/System Identification: Provide equipment identification nameplates complying with Division 16 Section 16400 "Electrical Identification".

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**LIGHTING FIXTURES:**

Furnish and install all lighting fixtures as indicated on the drawings. Fixtures shall be complete with lens or reflector, lamps, and wired ready for operation at the completion of installation. All fixtures shall have UL approval under their latest rulings indicating that fixture is approved for the intended usage. This Contractor shall provide proper fixture frames to suit type and dimensions of ceilings, confirming ceiling data with Plans, Architectural RCP, and General Contractor prior to ordering fixtures.

All fixtures shall be self-supporting, independent of the suspended ceiling. Fixtures shall be secured to the structure at a minimum of two points at opposing ends by wire equal to gauge of wire suspending the ceiling. Where fixture channels are joined to form a continuous length, provide one hanger at each end of the run and at each joint. Damaged fixtures shall be replaced at Contractor's expense. All fixtures shall be wired with a "Luminaire Cable" that contains the 0-10v dimming conductors.

**ELECTRONIC DRIVERS/BALLASTS:**

LED ballasts shall be high efficiency factor electronic ballasts where indicated on schedule, designed for rapid start operation for LED lamps. 70% LED lumen maintenance at 60,000 hours (L70/60,000). 0-10V dimming driver, dims to 10% and contains non-isolated dimming leads. Electronic ballast shall have a frequency of operation of 20 KHZ or greater and operate without visible flicker. Driver/Ballast shall be UL listed Class P, CSA certified, sound rated "A", withstand line transients as defined in ANSE/IEEE C62-41 Category A, and meet FCC requirements of Rules and Regulations, Part 18 for non-consumer equipment. Electronic ballast casing temperature shall not exceed a 25°C rise over 40°C ambient temperature or not exceed 85°C total. Electronic ballasts shall be by Advance Transformer Co., model Mark V or approved equal by Motorola or Magnetek.

**LAMPS:**

All lamps shall be as manufactured by Sylvania, Phillips, or General Electric Co.. Incandescent lamps shall be inside frosted 130V extended service unless otherwise noted. The Contractor shall be responsible for replacing all lamps which burn out during warranty period starting after Owner accepts project.

Unless indicated otherwise on drawings, LED and/or fluorescent lamps shall have energy saving drivers/ballasts, and a 4000 K color temperature with a color rendering index of 80 or better.

High pressure sodium lamps shall be GE "Lucalox" series or equal with median value of rated life no less than 24,000 hours.

**EMERGENCY LIGHTING:**

Furnish and install specified battery-powered emergency lighting units where indicated on the plans. Emergency lighting unit shall comply with the State of North Carolina Department of Insurance Document entitled "Requirements for Battery Powered Emergency Lighting Units" all subsequent addenda. Fixture shall have test light and switch accessible and visible from floor.

**EXIT LIGHTING:**

Furnish and install LED emergency exit sign with battery backup, brown-out protection, pilot light, test switch, and regulated power supply, where indicated on the plans unless specified otherwise. Exit signs shall comply

with the State of North Carolina Department of Insurance Document entitled "Requirements for Electrically Powered Exit Signs" dated 20 March 1995 and all subsequent addenda.

**EXIT & EMERGENCY LIGHTING CONTROLS:**

Contractor shall make provisions for Building Automation System (BAS) under Division 15 to exercise batteries on 21 to 28 day cycles. Coordinate with MC during rough-in as required with junction box for low voltage input to contactor.

**LIGHTING CONTACTORS:**

Each lighting contactor shall have heavy-duty ballast load rated contacts. Each contactor shall be normally closed contacts with mechanically held operators for open position, and silver cadmium oxide double break contacts. Contacts shall be field convertible with normally open and normally closed indicators. Each contactor shall be UL listed and CSA certified. All new lighting contactors for each new building shall be housed in a properly sized NEMA-1 enclosure with fully hinged and lockable door.

**OUTDOOR LIGHTING CONTROLS:**

For outdoor lighting applications, furnish and install contactors rated for load and photocells. Contractor shall make provisions for Building Automation System (BAS) or energy management control. Coordinate with MC during rough-in as required with junction box for low voltage input to contactor.

Photocells where indicated on drawing, shall be mounted in weather-proof enclosure under eastern facing eaves/overhangs with turn-on / off operations at 3-5 fc. Photocell shall be intermatic type K4221, for 120V and K4233 for 277V applications. Acceptable manufacturers are Tork, Intermatic, or Paragon. Photo cells shall not control luminaires directly all luminaires shall be controlled through a lighting contactor. Coordinate photocell specified with contactor coil rating.

*END OF SECTION*

**FIRE ALARM SYSTEM EXPANSION**

Furnish and install all labor, materials and programming to expand the existing fire alarm system to accommodate the new devices being added for the Renovation or Addition to have a complete and operational campus Fire Alarm system at project's end.

The Scope of Work shall include:

- a. Provide and install all notification and activation appliances as indicated on the plans, required by the local AHJ and as required by the North Carolina Building Codes. Education occupancies require voice notification devices.
- b. Provide a complete set of Shop drawings including wiring diagrams and battery calculations. Provide signal booster panels or battery booster panels as required for a fully functional system. Coordinate any 120V power requirements and locations with the electrical contractor.
- c. Fire alarm cabling shall match existing cabling for type and class. Cables shall be in conduit or shall be plenum rated. They shall be supported by a cable tray or j-hooks at a minimum of 6'-0" on center spacing to prevent droops and sags. FA cabling shall not be allowed to rest on ACT ceiling tiles, grid or lights.
- d. Provide and install magnetic door holders at main corridor connections to other buildings or wings and as indicated on plans. Install a ceiling mounted smoke detector on each side of each magnetically held door. If required, coordinate any 120V power requirements and locations with the electrical contractor.
- e. In educational facilities, manual stations shall be provided with surface mounted clear polycarbonate covers with an integral sounder base (95 dB minimum). Power for sounder base shall be hard wired from the fire alarm system, battery powered sounder bases shall not be acceptable. STI Stopper II model STI-1130-PULL shall be the basis of design. Approved equals by other manufacturers are acceptable.
- f. Notify engineer a minimum of 3 days prior to doing testing for the authority having jurisdiction.

Fire Alarm System components shall be installed by a factory-authorized service organization with minimum five years of successful public school installation experience and licensed in N.C.

Fire Alarm System equipment and devices shall be by Notifier to match existing school system equipment.

*END OF SECTION*

**DATE:** \_\_\_\_\_

**TIME:** \_\_\_\_\_

**SERVICE ORGANIZATION**

**PROPERTY NAME (USER)**

NAME: \_\_\_\_\_

NAME: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

REPRESENTATIVE: \_\_\_\_\_

OWNER CONTACT: \_\_\_\_\_

LICENSE NO.: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

**MONITORING ENTITY**

**APPROVING AGENCY**

CONTACT: \_\_\_\_\_

CONTACT: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

TELEPHONE: \_\_\_\_\_

MONITORING ACCOUNT REF. NO.: \_\_\_\_\_

**TYPE TRANSMISSION**

- ]-McCulloh
- ]-Multiplex
- ]-Digital
- ]-Reverse Priority
- ]-RF
- ]-Other (Specify)

\_\_\_\_\_  
\_\_\_\_\_

**SERVICE**

- ]-Weekly
- ]-Monthly
- ]-Quarterly
- ]-Semiannually
- ]-Annually
- ]-Other (Specify)

\_\_\_\_\_  
\_\_\_\_\_

PANEL MANUFACTURER: \_\_\_\_\_

MODEL NO.: \_\_\_\_\_

CIRCUIT STYLES: \_\_\_\_\_

NO. OF CIRCUITS: \_\_\_\_\_

SOFTWARE REV: \_\_\_\_\_

LAST DATE SYSTEM HAD ANY SERVICE PERFORMED: \_\_\_\_\_

LAST DATE THAT ANY SOFTWARE OR CONFIGURATION WAS REVISED: \_\_\_\_\_

**ALARM-INITIATING DEVICES AND CIRCUIT INFORMATION**

**QTY OF**

**CIRCUIT STYLE**

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

MANUAL STATIONS  
ION DETECTORS  
PHOTO DETECTORS  
DUCT DETECTORS  
HEAT DETECTORS  
WATERFLOW SWITCHES  
SUPERVISORY SWITCHES  
OTHER (SPECIFY): \_\_\_\_\_  
\_\_\_\_\_

Figure 7-5.2.2 Inspection and Testing Form. 1996 Edition

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**NATIONAL FIRE ALARM CODE**

**ALARM NOTIFICATION APPLIANCES AND CIRCUIT INFORMATION**

QTY OF	CIRCUIT STYLE	
_____	_____	BELLS
_____	_____	HORNS
_____	_____	CHIMES
_____	_____	STROBES
_____	_____	SPEAKERS
_____	_____	OTHER (SPECIFY): _____

NO. OF ALARM INDICATING CIRCUITS: \_\_\_\_\_

ARE CIRCUITS SUPERVISED?     YES     NO

**SUPERVISORY SIGNAL-INITIATING DEVICES AND CIRCUIT INFORMATION**

QTY OF	CIRCUIT STYLE	
_____	_____	BUILDING TEMP.
_____	_____	SITE WATER TEMP.
_____	_____	SITE WATER LEVEL
_____	_____	FIRE PUMP POWER
_____	_____	FIRE PUMP RUNNING
_____	_____	FIRE PUMP AUTO POSITION
_____	_____	FIRE PUMP OR PUMP CONTROLLER TROUBLE
_____	_____	FIRE PUMP RUNNING
_____	_____	GENERATOR IN AUTO POSITION
_____	_____	GENERATOR OR CONTROLLER TROUBLE
_____	_____	SWITCH TRANSFER
_____	_____	GENERATOR ENGINE RUNNING
_____	_____	OTHER: _____

**SIGNALING LINE CIRCUITS**

Quantity and style (See NFPA 72, Table 3-6) of signaling line circuits connected to system:

Quantity \_\_\_\_\_ Style(s) \_\_\_\_\_

**SYSTEM POWER SUPPLIES**

- a. Primary (Main): Nominal Voltage \_\_\_\_\_, Amps \_\_\_\_\_  
 Overcurrent Protection: Type \_\_\_\_\_, Amps \_\_\_\_\_  
 Location (Panel Number): \_\_\_\_\_  
 Disconnecting Means Location: \_\_\_\_\_
- b. Secondary (Standby): \_\_\_\_\_  
 Storage Battery: Amp-Hr. Rating \_\_\_\_\_  
 Calculated capacity to operate system, in hours: \_\_\_\_\_ 24 \_\_\_\_\_ 60 \_\_\_\_\_  
 Engine-driven generator dedicated to fire alarm system: \_\_\_\_\_  
 Location of fuel storage: \_\_\_\_\_

**TYPE BATTERY**

- Dry Cell
- Nickel-Cadmium
- Sealed Lead-Acid
- Lead-Acid
- Other (Specify)

c. Emergency or standby system used as a backup to primary power supply, instead of using a secondary power supply:

\_\_\_\_\_ Emergency system described in NFPA 70, Article 700  
 \_\_\_\_\_ Legally required standby described in NFPA 70, Article 701  
 \_\_\_\_\_ Optional standby system described in NFPA 70, Article 702, which also meets the performance requirements of Article 700 or 701.

**Figure 7-5.2.2 Inspection and Testing Form (continued).  
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**PRIOR TO ANY TESTING**

**NOTIFICATIONS ARE MADE:**

	YES	NO	WHO	TIME
MONITORING ENTITY	[ ]	[ ]		
BUILDING OCCUPANTS	[ ]	[ ]		
BUILDING MANAGEMENT	[ ]	[ ]		
OTHER (SPECIFY)	[ ]	[ ]		
AHJ (NOTIFIED) OF ANY IMPAIRMENTS	[ ]	[ ]		

**SYSTEM TESTS AND INSPECTIONS**

TYPE	VISUAL	FUNCTIONAL	COMMENTS
CONTROL PANEL	[ ]	[ ]	
INTERFACE EQ.	[ ]	[ ]	
LAMPS/LEDS	[ ]	[ ]	
FUSES	[ ]	[ ]	
PRIMARY POWER SUPPLY	[ ]	[ ]	
TROUBLE SIGNALS	[ ]	[ ]	
DISCONNECT SWITCHES	[ ]	[ ]	
GROUND FAULT MONITORING	[ ]	[ ]	

**SECONDARY POWER**

TYPE	VISUAL	FUNCTIONAL	COMMENTS
BATTERY CONDITION	[ ]	[ ]	
LOAD VOLTAGE	[ ]	[ ]	
DISCHARGE TEST	[ ]	[ ]	
CHARGER TEST	[ ]	[ ]	
SPECIFIC GRAVITY	[ ]	[ ]	

**TRANSIENT SUPPRESSORS** [ ] [ ]

**REMOTE ANNUNCIATORS** [ ] [ ]

**NOTIFICATION APPLIANCES**

AUDIBLE	[ ]	[ ]	
VISUAL	[ ]	[ ]	
SPEAKERS	[ ]	[ ]	
VOICE CLARITY	[ ]	[ ]	

**INITIATING AND SUPERVISORY DEVICE TESTS AND INSPECTIONS**

LOC. & S/N	DEVICE TYPE	VISUAL CHECK	FUNCTIONAL TEST	FACTORY SETTING	MEAS. SETTING	PASS	FAIL
		[ ]	[ ]			[ ]	[ ]
		[ ]	[ ]			[ ]	[ ]
		[ ]	[ ]			[ ]	[ ]
		[ ]	[ ]			[ ]	[ ]
		[ ]	[ ]			[ ]	[ ]
		[ ]	[ ]			[ ]	[ ]

COMMENTS: \_\_\_\_\_

\_\_\_\_\_

Figure 7-5.2.2 Inspection and Testing Form (continued). 1996 Edition

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NATIONAL FIRE ALARM CODE

EMERGENCY COMMUNICATIONS EQUIPMENT	VISUAL	FUNCTIONAL	COMMENTS
------------------------------------	--------	------------	----------



PHONE SET	[ ]	[ ]	_____
PHONE JACKS	[ ]	[ ]	_____
OFF-HOOK INDICATOR	[ ]	[ ]	_____
AMPLIFIER(S)	[ ]	[ ]	_____
TONE GENERATOR(S)	[ ]	[ ]	_____
CALL-IN SIGNAL	[ ]	[ ]	_____
SYSTEM PERFORMANCE	[ ]	[ ]	_____

	VISUAL	DEVICE OPERATION	SIMULATED OPERATION
<b>INTERFACE EQUIPMENT</b>			
(SPECIFY)	[ ]	[ ]	_____
(SPECIFY)	[ ]	[ ]	_____
(SPECIFY)	[ ]	[ ]	_____

<b>SPECIAL HAZARD SYSTEMS</b>			
(SPECIFY)	[ ]	[ ]	_____
(SPECIFY)	[ ]	[ ]	_____
(SPECIFY)	[ ]	[ ]	_____

SPECIAL PROCEDURES: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

ON/OFF PREMISES MONITORING:	YES	NO	TIME	COMMENTS
ALARM SIGNAL	[ ]	[ ]	_____	_____
ALARM RESTORAL	[ ]	[ ]	_____	_____
TROUBLE SIGNAL	[ ]	[ ]	_____	_____
SUPERVISORY SIGNAL	[ ]	[ ]	_____	_____
SUPERVISORY RESTORAL	[ ]	[ ]	_____	_____

NOTIFICATIONS THAT TESTING IS COMPLETE:	YES	NO	WHO	TIME
BUILDING MANAGEMENT	[ ]	[ ]	_____	_____
MONITORING AGENCY	[ ]	[ ]	_____	_____
BUILDING OCCUPANTS	[ ]	[ ]	_____	_____
OTHER (SPECIFY)	[ ]	[ ]	_____	_____

THE FOLLOWING DID NOT OPERATE CORRECTLY: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

SYSTEM RESTORED TO NORMAL OPERATION: DATE \_\_\_\_\_ TIME \_\_\_\_\_

**THIS TESTING WAS PERFORMED IN ACCORDANCE WITH APPLICABLE NFPA STANDARDS.**

NAME OF INSPECTOR: \_\_\_\_\_ DATE: \_\_\_\_\_ TIME: \_\_\_\_\_  
 SIGNATURE: \_\_\_\_\_  
 NAME OF OWNER OR REPRESENTATIVE: \_\_\_\_\_  
 DATE: \_\_\_\_\_ TIME: \_\_\_\_\_  
 SIGNATURE: \_\_\_\_\_

**Figure 7-5.2.2 Inspection and Testing Form (continued).  
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**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**TESTS:**

Test all lines to be concealed before burying or covering with new construction. Tests shall include proper operation of lights, receptacles, and equipment, continuity of conduit system, insulation leakage and impedance, elimination of motor single phasing or reverse rotation, and ground system resistance (see also Section 16400).

After the interior wiring system is completed and at such time as the Engineer or Owner's representative may direct, the Contractor shall conduct an operating test for approval. The tests shall be performed in the presence of the authorized representative of the Engineer and the installation shall be demonstrated to operate in accordance with the requirements of this specification. The Contractor shall furnish all instruments and personnel required for the test. The Contractor shall have sufficient tools and personnel available at the scheduled inspection to remove panel fronts, device plates, etc., as required for proper inspection of equipment, devices and wiring installation as may be required by the inspectors. Any material or workmanship which does not meet with approval of the engineer shall be promptly removed, repaired or replaced as directed, at no additional cost to the Owner.

**ADJUSTMENTS:**

Adjustments shall include load balancing of all electrical phases, at devices and panels. Balance all panelboards so that the maximum deviation of any one phase from the average of all the phases shall not exceed 10%. Re-type circuit directory as required after completion of adjustment.

**CLEANING AND PAINTING:**

Prior to final inspection, all equipment having factory finishes shall be thoroughly cleaned inside and outside. All damaged surfaces shall be replaced or refinished by Contractor, with paint same as original manufacturer. Engineer shall determine whether the damaged surface is to be replaced or painted.

**RECORD DRAWINGS:**

The Contractor shall maintain accurate records of all deviations in work as actually installed from work indicated on the drawings. On completion of the project, two (2) complete sets of marked-up prints shall be delivered to the Architect.

**OPERATING AND MAINTENANCE INSTRUCTIONS:**

Unless directed otherwise elsewhere in these specifications, the Contractor shall compile and bind three sets of all manufacturer's instructions and descriptive literature on all items of equipment furnished under this work. These instructions shall be delivered to the Engineer for approval prior to final inspection. Instructions shall include operating and testing procedures and a parts list of all equipment. The Contractor shall instruct the Owner's personnel in the proper operation of all systems and equipment. The front and side of the binder shall be titled "Electrical Operating and Maintenance Instructions", with name of the job and firm name of the Contractor.

**WARRANTY:**

The Contractor shall submit upon completion of the work, a warranty by his acceptance of the contract, that all work installed will be free from defects in workmanship and materials. If, during the period of one year, or as otherwise specified from date of Certificate of Completion and acceptance of work, any such defects in

workmanship, materials, or performance appear, the Contractor shall, without cost to the Owner, remedy such defects within reasonable time to be specified in notice from the Architect. In default, the Owner may have such work done and charge cost to Contractor.

*END OF SECTION*

*END OF SPECIFICATIONS*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**SCOPE OF WORK:**

The scope of work consists of the furnishing and installing all materials, labor, and equipment required for the existing Low Voltage systems (Voice, Data, Intercom, Security and Door Access Control) as indicated on the plans for complete and operational systems including other interconnected Low Voltage systems. The Technology Contractor (hereafter referred to as "the Contractor", or Technology Contractor) shall verify and certify that the systems are complete and functioning properly (Existing and/or New). The Contractor shall note that all items of equipment are specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on the drawings and as required for complete systems.

**DESCRIPTION OF WORK:**

It is the purpose of this specification to require the furnishing of the highest quality materials, equipment, and workmanship available, to fulfill the requirements of the work specified herein.

The Technology Systems encompass the Voice/Data Network Systems, and Intercom, as specified in Division 17. The Technology System shall provide a Telephone, Classroom and Administrative Intercommunication System, and a collapsed Fiber Optic Backbone / Cat 6 Ethernet Data Infrastructure. Other Low Voltage systems shall provide HVAC scheduling via a master time clock, door access control, security camera recording and notification of break-ins according to the counties standard operational procedure. Work Included as follows:

1. The work consists of providing all labor, equipment, supplies, materials, and incidentals and in performing all operations necessary for the "TURNKEY", fully operational, and completed work for the expansion of the existing Low Voltage Technology Systems, in complete accordance with the Contract Documents.
2. The base bid work shall include, but not be limited to, the following:
  - a. Provide all appropriate licenses for system as installed
  - b. Coordination of the Raceway installation with Division 16 Contractor
  - c. Furnish and Install specified data network system
  - d. Furnish and Install all PA and Sound Intercommunication Systems. Dedicated local sound systems for Auditoriums, Gymnasiums and Cafeterias shall be provided in the electrical contract, i.e. not provided within the scope of this contract, but requires coordination and inter-connection by this contractor.
  - e. Furnish and Install the VOIP Telephone equipment compatible with the existing System.
  - f. Provide product demonstrations as required by the Owner
  - g. Coordination with General Contractor, and all other trades.

3. Technology systems shall be bid as part of the Construction Contract.

It is the intention of the Specifications and Drawings to call for finished work, tested and ready for operation.

Any apparatus, appliance, material, or work not shown on the drawings but mentioned in the specifications, or vice versa, or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered, and installed by the Contractor without additional expenses to the Owner.

Minor details not usually shown or specified, but necessary for proper installation and operation, shall be included in the Contractor's estimate, the same as if herein specified or shown.

With submission of bid, the Contractor shall give written notice to the Architect of any materials or apparatus believed inadequate or unsuitable, in violation of laws, ordinances, rules, and any necessary items or work omitted. In the absence of such written notice, it is mutually agreed that the Contractor has included the cost of all required items in his proposal, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensation.

NOTICE TO BIDDERS, INSTRUCTIONS TO BIDDERS, SUPPLEMENTARY INSTRUCTIONS, GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, SPECIAL CONDITIONS, GENERAL REQUIREMENTS bound in the front of this document are included as a part of the specifications for this work.

**DRAWINGS AND SPECIFICATIONS:**

These drawings are diagrammatic and indicate the general arrangement of fixtures, equipment, and work included in the contract. Consult the architectural, structural, mechanical and electrical drawings and details for exact location and dimensions of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.

The Contractor shall follow drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Architect shall be notified before proceeding with installation. If directed by the Architect, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.

The plans and these specifications are intended to describe, imply and convey the materials and equipment as well as necessary labor, required for the installation as outlined in the paragraph entitled "Scope of Work". Any omissions from either the drawings or these specifications are unintentional, and it shall be the responsibility of the Contractor to call to the attention of the Architect or Engineer any pertinent omissions before submission of a bid. The drawings which accompany these specifications are not intended to show in complete detail every fitting which may be required; however wherever reasonable implied by the nature of the work, any such material or equipment shall be installed by this Contractor as a part of his contract price. In no case will any extra charge be allowed unless authorized in writing by the Architect or Engineer.

The Contractor shall arrange with the General Contractor for required concrete and masonry chases, openings, and sub-bases so as not to delay progress of work. Work shall be installed sufficiently in advance of other construction to conceal piping and to permit work to be built in where required.

**WORK SCHEDULE:**

The contractor will coordinate all work schedules with the General Contractor and/or Architect. All efforts should be made to complete cable installation prior to the installation of ceiling tile in new or modernized construction.

**DEFINITIONS:**

It shall be understood and agreed by all parties that where the following terms appear, these definitions apply:

"Furnish" - to supply or give.

"Install" - to place, establish or fix in position.

"Provide" - to furnish and install as defined above.

The term "Bidder" refers to those parties who are submitting proposals for the work set forth in this document.

The term "Contractor" refers to the successful Bidder and to any work or issues after the award of the contract.

The term "Owner" refers to the County School System or its designated agent.

**GENERAL REFERENCE STANDARDS:**

The installation shall comply with the following:

1. NFPA No. 70 National Electric Code (NEC), Current Edition
2. State and Local Building codes
3. National Fire Protection Agency (NFPA) No. 101, Life Safety Code, latest Edition
4. UL Directory of Electrical Construction Materials
5. BICSI Telecommunications Distribution Methods Manual

The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, drawings (in addition to contract drawing and documents) in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not shown on drawings and / or specified.

All work and materials under this section shall be in strict compliance with more stringent requirements of the North Carolina State Building Code, including the National Electrical Code, NFPA 101-Life Safety Code, Regulations of the State Fire Marshall, and requirements of the local utility company

**STANDARD FOR MATERIALS:**

Furnish and install new and undamaged materials conforming to the applicable standard. The standards and publications of the following entities and applicable to materials specified herein:

1. Underwriters Laboratories (UL)

2. Institute of Electrical and Electronic Engineers (IEEE)
3. American National Standards Institute (ANSI)
4. Electronics Industry Association (EIA)
5. Telecommunications Industry Association
6. Electronics Testing Laboratories, Inc. (ETL)

Materials referenced by manufacturer or trade name are cited for the quality of the product and are not intended to limit competitive bidding. The Bidder, at their option, may bid to furnish alternative products which are equal in quality and performance; however, all substitutions must be approved by Owner.

**PERMITS AND FEES:**

The Contractor shall give all necessary notices, including electric and telephone utilities, obtain all permits, and pay all government taxes, fees, and other costs, including utility connections or extensions in connection with his work file all necessary plans, prepare all documents, and obtain all necessary approvals of all governmental departments having jurisdiction at each phase of construction as required; obtain all required certificates of inspection for his work and deliver same to the Architect before request for acceptance and final payment for the work.

**FCC APPROVAL:**

The system shall be approved for direct interconnection to the telephone utility under Part 68 of FCC rules and regulations. Systems which are not FCC approved or utilized and intermediary device for connection shall not be considered. Provide the FCC registration number of the system being proposed as a part of the proposal process.

**PRODUCT DEMONSTRATIONS:**

The Systems Contractor may be required to provide product demonstrations and interviews with the Owner and his representatives or may be required to provide side-by-side demonstrations with other vendors. These demonstrations may be required before a contract is issued. Contractors should be prepared to demonstrate each feature called for in these specifications.

**VERIFICATION OF DIMENSIONS, DETAILS, EXISTING FIELD CONDITIONS:**

The Contractor shall visit the premises prior to bidding. and thoroughly familiarize himself with all details of the work, working conditions, verify dimensions in the field, provide advice of any discrepancy, and submit shop drawings of any changes he proposes to make in quadruplicate for approval before starting any work. The Contractor shall install all equipment in a manner to avoid building interference.

**Telephone Equipment**

New equipment shall be fully compatible with the existing system. Field verify exact phone required for the existing system.

For reference: Current school system standard materials for telephone systems includes YEALINK IP Office Communication Manager Latest Release, with telephony components, data networking capability and WAN interface as shall meet minimum functionality required within these specifications. Telephones and handsets shall be YEALINK products for VoIP applications.

Telephones for classrooms, resource and teacher workrooms shall be YEALINK T40P, quantity as required for one device at each location.

Telephones in the Administration Area, Media center (including ancillary rooms) shall be YEALINK T42G, quantity as required for one device at each outlet location.

Provide one YEALINK T48G telephone at Administration Area secretary location.

**SHOP DRAWINGS:**

The Contractor shall submit a minimum of five (5) copies of the shop drawings to the Architect for approval within thirty (30) days after the award of the general contract. If such a schedule cannot be met, the Contractor may request in writing for an extension of time to the Architect. If the Contractor does not submit shop drawings in the prescribed time, the Architect has the right to select the equipment.

Provide manufacturer's cuts of items to be provided under this Contract. The shop drawings shall be neatly bound in five (5) sets and submitted to the Architect with a letter of transmittal. The letter of transmittal shall list each item submitted along with the manufacturer's name.

Approval rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are approved, said approval does not mean that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the contract drawings and specifications.

**SUBMITTALS:**

A. Prior to proceeding with the work:

A complete schedule of ALL equipment and materials which are to be furnished for the work. Accompanying the schedule shall be manufacturer's specification or cut sheets for all major components listed in Section 2 of this specification.

1. Shop Drawings

Complete shop drawings for all systems and assemblies specified. Each drawing shall have a descriptive title and all subparts of each drawing shall be labeled. All drawings shall have the name and location of the project and the Systems Contractor's name in the title block.

2. Cabinets & Assemblies

Complete scaled drawings of all equipment racks, consoles, special assemblies, etc. Each drawing shall show all equipment with its manufacturer and model number.

3. Device Locations

Complete scaled drawings detailing installation locations of all equipment, such as control panels, plug panels, TV monitors, equipment racks, speakers, etc. All conduits with cable quantities and types and all terminal block locations shall also be indicated.

4. Device Layout

Complete scaled drawings detailing all device plates, plug panels, input/output panels, rack panels and custom components to be fabricated by the Systems Contractor. Include the same details for all custom or non-standard components to



be furnished by vendor/manufacturers of the Systems Contractor. Show all connectors, mounting devices and engraving detail on these drawings.

5. System Diagrams

Detailed one line drawing of all systems. Each system drawing shall detail the field wiring and wiring within racks, consoles, control panels, devices, speaker assemblies, etc. Each drawing shall show proposed (and eventually as built) circuit numbers for all cables and terminal connections. Provide typical wiring termination details for all devices.

6. Systems Contractor job references and key employee résumés, as described in the Contractor Qualifications portion of this specification.

C. Prior to proceeding with respective portions of work:

1. Diagrams for AC power low voltage control switching.
2. Details and descriptions of any other aspect of the system which differ from the contract drawings due to field conditions or due to the equipment furnished.
3. Submittal as otherwise noted on the drawings and/or as noted herein.
7. Approved shop drawings and instruction brochures, including schematic diagrams for all electronic devices, shall be present at the job site during the period set aside for system testing.
8. Notebooks of operating instructions shall be prepared for the Owner as described herein.

C. At Project Completion

1. As-Builts

Prior to final acceptance, provide three complete sets of drawings showing all cable numbers and construction details in accordance with the actual system installation. Revise all shop drawings to represent actual installation conditions.

2. Operation and Maintenance Manuals

Prior to final acceptance, provide three complete sets of operation and maintenance manuals for the system. The operation manual shall contain all instruction necessary for the proper operation of the installed system and manufacturers' instruction. The maintenance manual shall contain all "proof of performance" information as required in Section 3, and all manufacturers' maintenance information, and copies of non-priority computer programs and system set up disks documenting all programmable features for the installed system.

**COORDINATION WITH OTHER TRADES:**

Coordinate all work required under this section with work of other sections of the specifications to avoid interference. Bidders are cautioned to check their equipment against space available as indicated on drawings, and shall make sure that proposed equipment can be accommodated. If interferences occur, Contractor shall bring them to attention in writing, prior to signing of contract; or, Contractor shall at his own expense provide proper materials, equipment, and labor to correct any damage due to defects in his work caused by such interference.

**INSPECTION AND CERTIFICATES:**

On the completion of the entire installation, the approval of the Architect and Owner shall be secured, covering the installation throughout. The Contractor shall obtain and pay for Certificate of Approval from the public authorities having jurisdiction. A final inspection certificate shall be submitted to the Architect prior to final payment. Any and all costs incurred for fees shall be paid by the Contractor.

**EQUIVALENTS:**

When material or equipment is mentioned by name, it shall form the basis of the Contract. When approved by the Architect in writing, other material and equipment may be used in place of those specified, but written application for such substitutions shall be made to the Architect as described in the Bidding Documents. The difference in cost of substitute material or equipment shall be given when making such request. Approval of substitute is, of course, contingent on same meeting specified requirements and being of such design and dimensions as to comply with space requirements.

**CUTTING AND PATCHING:**

On new work, the Contractor shall furnish sketches to the General Contractor showing the locations and sizes of all openings and chases, and furnish and locate all sleeves and inserts required for the installation of the electrical work before the walls, floors, and roof are built. This Contractor shall be responsible for the cost of cutting and patching where any items were not installed or where incorrectly sized or located. See also Section 01050.

**CONTRACTOR QUALIFICATIONS:**

- A. The Contractor or subcontractor must be a "Systems Contractor" who has been regularly engaged in the furnishing and installation of commercial and industrial sound, communications and telephone systems and related visual communications systems for a period of at least the last three (3) years and who can show evidence of successfully completing, with its present staff, at least three (3) projects of similar size and scope, including the media management addition. The Systems Contractor, not its employees, must meet these contractor qualifications. With the proposal, provide a list of jobs completed, with contact, address and phone number and the A/V Contractors key employees assigned to the project, listing their responsibilities during the job and the length of time with the contractor in this capacity.
- B. The Systems Contractor shall demonstrate to the satisfaction of the Architect/Engineer and Owner that it has:
  - 1. Adequate plant and equipment to pursue the work properly and expeditiously.
  - 2. Adequate staff and technical experience to implement the work.
  - 3. Suitable financial status to meet the obligations of the work.
  - 4. Technically capable and factory trained service personnel at a contractor owned service facility within one hundred (100) mile radius of the project site, to provide routine and emergency service for all products used in the project.
- C. The Systems Contractor shall:
  - 1. Be bondable.

2. Hold a SPLV Contractors License which is accepted as valid within the State of North Carolina.
  3. Be a factory authorized sales and installation contractor for all products used in the project.
- D. Any contractor, who intends to submit a proposal for this work and does not meet the requirements of the "Contractor Qualifications" paragraph(s) above, shall employ the services of a "Systems Contractor" who does meet the requirements and who shall furnish the equipment, shop fabricate the equipment racks and subassemblies, make all connections to equipment and equipment racks, make all connections to remote controls and connection panels, and continuously supervise the installation and connections of all system cable and equipment.
- E. A subcontractor so employed as the "Systems Contractor" shall be acceptable to the Owner and/or Architect/Engineer and shall be identified in the proposal.

**QUALITY ASSURANCE:**

A. General

All equipment and materials required for installation under these specifications shall be new (less than 1 year from date of manufacture) and without blemish or defect.

B. Specific

Each major component of equipment shall have the manufacturer's name, address and model number on a plate securely affixed in a conspicuous place. NEMA code ratings, UL label, or other data which is die-stamped into the surface of the equipment shall be easily visible.

C. Substitutions

It is not the intent of these specifications to limit or restrict submission of proposals for products by other manufacturers but to set a baseline of operational performance and functions which all bidders must meet.

- D. Where a specific piece of equipment has been discontinued and/or replaced by a new model, submission of the new model does not guarantee acceptance. Substitute items shall require evaluation by the Architect/Engineer, Owner or their agent prior to acceptance.

- E. If substitute equipment is allowed even by an approved submittal, the ITS Contractor shall be completely responsible for its use and for its ability to fulfill all intended functions in the completed systems. The ITS Contractor shall replace all such equipment with equipment listed by type and model number in the specifications if there is any evidence of equipment instability and/or incompatibility.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**PART 1: GENERAL**

**SCOPE OF WORK:**

This document provides specifications to be used in conjunction with network design drawings for installation of voice and for data cabling.

The Contractor shall furnish all labor, materials, tools, equipment and services necessary for and reasonably incidental to installation of specific voice and/or data cabling communications infrastructure. Work shall include all components for both a voice and data horizontal and riser cable plant from workstation outlet termination to wire closet termination. All cable plant components such as outlets, wiring termination blocks, racks, patch cables, etc. will be furnished, installed, and tested by the Contractor. The data cable plant is designed to support a 10BASE-T Ethernet building-wide computer network.

The scope of work includes all activities needed to complete the wiring and network intelligent hub equipment installation described in this document and the drawings.

The successful Bidder must be able to provide and install new equipment and materials in compliance with specifications contained in this document and accompanying drawings.

Any and all overtime (outside school hours) required to complete the scope of work within the time frame specified shall be included in the quoted price.

**VOICE AND DATA WIRING PLAN OVERVIEW:**

The cable system is based on the universal cabling concept. The same cables are installed to all workstations; connectors, adapters, and interconnections determine how the cable operates.

**COMMUNICATIONS DESIGN (CD) DRAWINGS:**

Communications design drawings show voice and data CNO locations, cable routing, and wire closet layout plans.

**WORK SCHEDULE:**

The contractor will coordinate all work schedules with the Architect. All efforts should be made to complete cable installation prior to the installation of ceiling tile in new or modernized construction.

**DEFINITIONS:**

The term "Bidder" refers to those parties who are submitting proposals for the work set forth in this document. The term "Contractor" refers to the successful Bidder and to any work or issues after the award of the contract.

The term "Owner" refers to County Schools IT personnel or its designated agent.

A "Communications Network Outlet" (CNO) refers to a specific communications termination location with "two or four port communications outlet", defined as a CNO containing 2 or 4 modular RJ-45 connectors. A "jack" refers to one modular RJ-45 connector. A "faceplate" is a decorative cover that covers the non-exposed portion of the jack and attaches to the outlet.

“Riser” refers to the cables interconnecting the wiring closets. Please note that in most cases the riser cables are physically a horizontal run between two closets.

**GENERAL REFERENCE STANDARDS:**

The installation shall comply with the following:

1. National Fire Protection Agency (NFPA) No.70, National Electric Code 2005 Edition
2. State and Local Building codes
3. National Fire Protection Agency (NFPA) No. 101, Life Safety Code, latest edition.
4. TIA/EIA 568A, 568B, 606, 607, and 569.
5. Building Industry Consulting Service International's (BICSI) Telecommunications Distribution Methods Manual

**CONSTRUCTION SUBMITTAL:**

In addition to the submittal requirements the Contractor must submit the following information during the execution of the project.

1. The Contractor must submit the manufacturer and model number for all suggested substitution of equipment specified for the work contracted. The Owner will determine acceptability of equipment at their discretion. For all cable components, the Owner will require certification that components are accepted for use in Ethernet networks, and meet all specifications as described.
2. The Contractor shall submit for approval samples of voice and data cable, fiber optic cable, patch cords, patch panels, faceplates and jacks. Samples shall be returned upon written request. The Owner shall have the right to reject any submittal that does not meet the specifications and intended use as determined by Owner.
3. Shop drawings showing proposed cable routing, closet detail design, rack design, MDF layout and other design details not specified in this document or Communications Design Drawings shall be submitted prior to any portion of the system installation for approval and to demonstrate compliance with the contract documents. Any departures from the original contract drawings should show details of such departures including changes in related portions of the project and the reasons therefore submitted with the shop drawings. Shop drawings must be provided showing details of all proposed fire-stops for four-hour rated walls. Approved departures recommended by the Contractor shall be made at no additional cost to Owner or shall result in a net decrease in cost. The Owner shall obtain the benefits of any cost reductions of these changes.
4. The Contractor shall submit as-built design drawings of the installed cable system including any design which deviates from the specified routes. As-built drawings shall include cable routes and labeling, patch panel configurations, IDC and MDF configurations, cross connect details, riser system, patch cord details, riser system, fiber storage and labeling. As-builts shall be turned over to the Owner as each section of the work is completed.

## **PART 2: PRODUCTS**

### **STANDARD FOR MATERIALS:**

Furnish and install new and undamaged materials conforming to the applicable standard. The standards and publications of the following entities and applicable to materials specified herein:

1. Underwriters Laboratories (UL)
2. Institute of Electrical and Electronic Engineers (IEEE)
3. American National Standards Institute (ANSI)
4. Electronics Industry Association (EIA)
5. Telecommunications Industry Association
6. Electronics Testing Laboratories, Inc. (ETL)

Materials referenced by manufacturer or trade name are cited for the quality of the product and are not intended to limit competitive bidding. The Bidder, at their option, may bid to furnish alternative products which are equal in quality and performance; however, all substitutions must be approved by Owner.

### **COMPLETENESS OF WORK:**

Furnish all material, labor, transportation, tools, equipment, and supervision to install and leave ready for operation a complete communications systems in accordance with these specifications and the accompanying drawings.

All offsets, bends fittings pull boxes, stems and supports for the complete installation are not indicated on the drawings. It shall be the Contractor's responsibility to furnish and install all offsets, bends, devices, raceway supports, and equipment for the complete installation.

### **COMPATIBILITY:**

Provide products which are compatible with other components in the system with which they must interface. Components and materials must fit into the confines indicated, leaving adequate clearance as required by applicable codes or manufacturer for adjustment, repair, or replacement.

### **PRODUCT HANDLING, DELIVERY, STORAGE:**

Ensure that all system equipment, devices, and materials arrive at the designated installation site in good condition, intact in factory package or crate. Any equipment found to be damaged will be removed from the project site and will be replaced by the Contractor at their expense.

Storage - Store all equipment, devices and materials in their factory containers or package until ready for use. Storage facilities will be a clean, dry and indoor space which provides protection against the weather. Avoid damage by condensation by providing temporary heating when required. Large reels of cable may be stored outdoors provided there is adequate protection from physical damage and the cable ends are properly sealed to prevent moisture ingress. The Bidder shall state how much space and floor loading will

be required. Storage related costs will be the responsibility of the Contractor. Coordinate all storage of materials and equipment with the Owner.

Handling - Handle all equipment, devices and materials carefully to prevent breakage, denting or scoring of the finish or cable jackets. Damaged materials will be removed from the project site, and replaced by the Contractor at no additional cost. No sheath cuts will be accepted. All cables must be installed with sheath intact to the point of termination.

The Bidders should note that strict limitations will be enforced on the size, weight, and arrangement of cable reels. In general, cable reels must be of a size to be lifted on the interior freight elevator, and fit through standard doorways.

Any cable found to be damaged or defective shall be replaced by the Contractor at no additional cost to the Owner.

### **DATA CABLE INFRASTRUCTURE**

#### **A. Twisted Pair Cable**

1. Cabling shall be unshielded twisted pair (UTP) and shall meet EIA/TIA-568, TSB-36 requirements for Category 6 (Security/Cameras, HVAC Controllers, and Data Port Drops) 6A (Wireless Access Points and Access Door Control). Provide UTP cable with the following minimum features:
  - a. Conductors: 24 AWG solid copper, 4 pair;
  - b. Impedance: 100 ohms +/-15% at 1-100 MHz;
  - c. DC Resistance: 25.7 ohms/1000 ft. maximum at 20 degrees C;
  - d. Mutual Capacitance: 14 pF/ft. nominal at 1 MHz;
  - e. Attenuation (per 1000 ft):
    - i. 2.0 dB at 1 MHz
    - ii. 3.7 dB at 4 MHz
    - iii. 6.0 dB at 10 MHz
    - iv. 7.6 dB at 16 MHz
    - v. 8.6 dB at 20 MHz
    - vi. 10.8 dB at 31.25 MHz
    - vii. 15.5 dB at 62.5 MHz
    - viii. 20.2 dB at 100 MHz
    - ix. 25.8 dB at 155 MHz
    - x. 29.8 dB at 200 MHz
    - xi. 41.2 dB at 300 MHz

2. Provide one "homerun" UTP cable between each data outlet port indicated on the drawings and the appropriate Local 100/1000 Switch
3. UTP cables shall not exceed 90 meters from the data outlet port to the appropriate 100/1000 Switch
4. Provide cable sheathing in the following color schemes:
  - Security/Cameras: Yellow
  - Data: Blue
  - Patch Cables: Blue
  - HVAC Controls: Purple
  - Wireless Access: Blue
  - Door Access Control: Yellow
  - Intercom: White
  - Fire Alarm: Red

**D. Data Station Outlet**

**1. Face plates**

- a. Provide Data Station Outlets as indicated on the drawings with the following features:
  - i. Single gang, flush mountable, stainless steel construction;
  - ii. Shall accept data, telephone, fiber optic, VGA, video, audio and blank insert modules;
  - iii. Shall have the capability to accept up to six individual ports;
  - iv. Inserts shall snap in and out from the front of the Data Station Outlet;
  - v. Face plates shall be supplied with pressure-sensitive icon labels;

**2. Inserts**

- a. Provide Data Port inserts with the following features:
  - i. RJ-45 type rated for Category 6;
  - ii. RJ-45 insert shall be configured to EIA-568A wiring standards;
  - iii. Attenuation through the RJ-45 port at 10/16 MHz shall be less than .015/.025 dB;
  - iv. Provide 110 style IDC terminations for all eight conductors of a UTP cable;
- b. Provide Telephone Inserts with the following features:
  - i. RJ-45 type rated for Category 6;
  - ii. RJ-45 insert shall be configured to USOC wiring standards;
  - iii. Provide 110 style IDC terminations for all six conductors of a UTP phone cable;



- c. Provide HDMI & Data inserts with the following features for all new wall mounted Monitors and Teacher's Stations:
  - i. Premanufactured HDMI Cables and inserts
  - ii. RJ-45 type rated for Category 6;

**E. Patch Panels**

1. Patch panels shall be provided at each new IDF room and/or switch closet for termination of all UTP and fiber optic cables. Patch panels shall have the following features:
2. Patch Panels for Twisted Pair Cable
  - a. Panels shall be mountable in EIA standard 19" equipment racks;
  - b. Panels shall be rated for Category 6;
  - c. Each panel shall provide a minimum of twenty-four RJ-45 ports in one rack space position (1RU);
  - d. Each RJ-45 port shall provide 110 style IDC terminations for all eight conductors of a UTP cable;
  - e. RJ-45 ports shall be configured to EIA-568A wiring standards;
  - f. Attenuation through the RJ-45 port at 10/16 MHz shall be .015/.025 dB;
  - g. Clearly label each patch point with the location of its associated data station port;
3. Provide a three (3) foot minimum Category 6 UTP patch cable for every Category 6 UTP data cable terminated at a patch panel. Install and neatly route patch cables between the panel and the hubs utilizing cable management hardware.
4. Patch Panels for Fiber Optic Cables
  - a. Panels shall be mountable in EIA standard 19" equipment racks;
  - b. Panels shall provide LC-LC feed-through connectors for termination of fiber optic strands;
  - c. Panels shall provide space for at least three feet of fiber optic cable management and excess patch cable storage in a pull-out drawer;
  - d. Clearly label each fiber optic LC patch position with the location of its origin;
5. Provide a 6-foot minimum fiber optic patch cable for every fiber hub or switch port in the system. Install and neatly route patch cables between the panel and the hubs, utilizing cable management hardware.
6. Provide horizontal cable management panels between each patch panel for twisted pair cable and vertical cable management panels for each data rack. Cable management panels shall be Panduit "WMP" series, or equal.

7. Provide fiber management systems at the panel location.
- F. Ethernet Switch at IDF and Switch Closet Locations or as shown on the drawings
  - G. Certification
    1. Systems Contractor shall be factory certified to install the Data Cabling Infrastructure. The Systems Contractor shall include a copy of the factory-provided certification with his submittal.

### **PART 3: EXECUTION**

Perform the work in accordance with acknowledged industry and professional standards and practices, and the procedures specified herein. Furnish and install all materials, devices, components, and equipment for complete operational systems.

#### **DEVIATIONS:**

No deviations shall be made from the drawings or specifications. Should the Contractor find at any time during the progress of the work, that in his judgement, conditions made desirable or necessary modifications in the requirements covering any particular item or items, he shall report such matters promptly to the Owner for his decision and instruction.

#### **COOPERATION BETWEEN TRADES:**

The communications work shall be scheduled with the work of the other trades to avoid delays, interference's, and unnecessary work. All other shall be notified of all openings, hangers, excavations and similar operations for the installation of communications work, is required under this section of the specifications. The work of other trades shall not be cut without first consulting the Owner. Any work damaged by those employed in the work under this section of the specifications shall be repaired using the services of the trade whose work is damaged at the cost of the Contractor.

The plans are diagrammatic and reference must be made to structural, architectural, and mechanical systems plans and actual construction. Work under this section shall be coordinated with the different trades so that interference between electrical raceways, piping, equipment, architectural, and structural work shall be avoided.

Clearly and completely specify all items and actions relative to the installation and operation of the proposed equipment that the Owner will be responsible for providing and/or performing.

The successful Bidder's project manager will be responsible for providing written reports to the Owner at the beginning of every week for the previous week's work completed and upcoming week's planned. Maintain a competent supervisor and supporting technical personnel, acceptable to the Owner, during the entire installation. Change of the supervisor during the project shall not be acceptable without prior written approval from the Architects.

Dress and permanently label all cables at each end using approved labels to ensure a neat and organized appearance.

Do not splice or otherwise re-terminate any cable used to fulfill the requirements of this specification other than at the main distribution frame and intermediate distribution cabinet. Riser cables will not contain intermediate splices.

Coordinate work with any other communications parties on-site, specifically, the LAN Installer, the Computer Installer, and other third parties whose work may affect or be affected by the cabling systems described herein.

During installation, the Owner and/or Representative will conduct periodic inspections to verify that cable installation is proceeding according to the guidelines specified in this document. Any deficiencies found will be properly corrected within 7 days by the Contractor at no additional expense to the Owner upon notification to the Contractor.

It is expected that overtime may be required to complete the scope of work in the time allocated. The Bidder must include all overtime in his price and no additional overtime charges will be accepted.

The Contractor will control litter at all times by keeping it in containers. The Contractor will remove any installation debris from the site and dispose of it properly. Major trash will be removed daily by the Contractor. All other cable-related trash, dust, dirt, etc. must be removed and cleaned prior to acceptance.

### **INSTALLATION OF SYSTEMS**

#### **A. Device Locations**

Locate all apparatus requiring adjustments, cleaning, or similar attention so that is shall be accessible for such attention. Equipment racks shall be positioned to permit full access for operation and service.

#### **B. Blank and Custom Panels**

Finish of blank panels and custom assembly panels shall match adjacent equipment panels as closely as possible.

#### **C. Markings**

Switches, connectors, jacks, receptacles, outlets, cables, and cable terminations shall be logically and permanently marked. Custom panel nomenclature shall be engraved, etched, or screened. Marking for these items are purposely detailed on the drawings to ensure consistency and clarity. Verify any changes in working type size, and/or placement with the Architect prior to marking.

#### **D. Environment**

The equipment specified herein is designed to operate in environments of normal humidity, dust, and temperature. Protect equipment and related wiring during installation where extreme environmental conditions can occur.

### **ELECTRICAL POWER**

#### **A. Grounding**

Review and coordinate electrical power system installation including grounding, with the Division 16 Prime Contractor to ensure proper operation of the system. All racks, cable tray, and devices shall be grounded to a common isolated grounding bar within each MDF or IDF. Additional grounding shall be installed where directed by the engineer.

#### **B. Verification**

Verify that all AC power circuits designated for the system are properly wired, phased, and grounded. Report in writing any discrepancies found to the Division 16 Prime Contractor for corrective action.

C. Equipment Rack

Provide distribution of electrical power within the equipment racks with a minimum of two spare AC receptacles per branch circuit, used in the racks. ICS Contractor shall provide and install 20 amp power strips in each data rack.

**CLEANING**

Clean all junction and terminal box interiors thoroughly before installing plates, panels, or covers.

**WIRING METHODS & PRACTICES**

A. Identification

All wires shall be permanently identified at each wire by marking with "E-Z" tape marker or equivalent.

B. Terminal Blocks

All terminal block connections shall be readily accessible. Not more than two wires connected to one terminal. Spare terminal blocks, equivalent to 10% of those in actual use shall be provided.

C. Splicing

Splicing of cables shall not be permitted between terminations of specified equipment.

D. Pulling Cable

Do not pull wire or cable through any box fitting or enclosure where change of raceway alignment or direction occurs. Do not bend conductors to less than recommended radius. Employ temporary guides, sheaves, rollers, and other necessary items to protect cables from excess tension, abrasion, or damaging bending during installation. All cables not in conduit shall be installed in J Hooks spaced no more than 5 feet apart.

E. Cable Tie

Form in a neat and orderly manner all conductors in enclosures and boxes, wire ways, and wiring troughs, providing circuit and conductor identification. Tie as required using T & B "Ty-Raps" (or equivalent) of appropriate size and type. Limit Spacing between ties to six inches and provide circuit and conductor identification at least once in each enclosure.

F. Service Loops

Provide ample service loops at each termination so that plates, panels, and equipment can be demounted for service and inspection.

G. Wiring Harnesses

1. All wires and cables used in assembling custom panels and equipment racks shall be formed into harnesses which are tied and supported in accordance with accepted Engineering practice.

2. Harnessed cables shall be formed in either a vertical or horizontal relationship to equipment, controls, components, or terminations.

## **EQUIPMENT RACKS**

### **A. General**

The equipment racks shall be considered as custom assemblies and shall be assembled, wired, and tested in a properly equipped shop maintained by the ICS Contractor. Assembly of racks on site shall not be permitted. Racks shall be B-Line model SB556084X-UFB or equal. Data closets shall have 18" B Line (or equal) ladder tray installed to allow for adequate cable support and service loops.

### **B. Equipment Location**

Placement of equipment in equipment racks, as indicated in the drawings, is for maximum operator convenience. Verify any changes in placement prior to assembly. All system components and related wiring shall be located with due regard for the minimization of induced electromagnetic and electrostatics noise, for the minimization of wiring length, for proper ventilation, and to provide reasonable safety and convenience for the operator.

### **C. Rack Installation**

Racks shall be installed plumb and square without twists in the frames or variations in level between adjacent racks.

### **D. Identification**

All terminal blocks, rack mounted equipment, and active slots of card frame systems shall be clearly and logically labeled as to their function, circuit, or system as appropriate. Labeling on manufactured equipment shall be engraved plastic laminate with white lettering on black or dark background that is similar to panel finish.

## **PART 4: TESTING**

### **TOOLS AND TEST EQUIPMENT**

The Contractor will provide all tools and test equipment required for installation and testing work. Test equipment will be maintained in accurate calibration and will display the dates of the last calibration and next scheduled calibration. The Contractor is responsible for performing all tests indicated at the end of each section.

For all tests, the Owner or its agent must be present at the beginning of testing and at such times as the owner deems appropriate. The Contractor shall be responsible for correcting any problems or defects discovered during testing.

### **DATA CABLE INFRASTRUCTURE TESTING**

1. Test each twisted pair cable segment (example: from the data station port through the patch bay and patch cable to the hub port connector). Publish a log of each test to verify that the cable segment passes the EIA/TIA-568 TEB-36 requirements for Category 6 compliance. Bind the test log in a booklet and turn the booklet over to the Owner. The test shall include:
  - a. Connector/cable continuity – line mapping;

- b. Cable segment length;
  - c. Dual near end cross talk (NEXT);
  - d. Attenuation at 100 MHz;
  - e. Attenuation per foot;
  - f. Pass/fail results of each portion of the test above.
2. Test each fiber optic strand segment (From each classroom or switch location to the MDF). Publish a log of each test to verify that the fiber segment passes the EIA/TIA-526-14 optical power loss measurement test. Bind the test log in a booklet and turn the booklet over to the Owner.

## **PART 5: COMMISSIONING**

### **SYSTEM DOCUMENTATION**

- A. Prior to final acceptance tests, submit to the Architect, three copies of an operating and maintenance manual for the system that has been installed. These manuals shall be used during the final acceptance testing of the system. Each manual shall contain the following information:
  1. As-built drawings
  2. Operations and maintenance manuals
  3. Single line diagrams showing levels throughout system and impedances

### **ACCEPTANCE TESTING**

- A. The Acceptance Testing shall be performed by the Owner or the Owner's agent. Coordinate this period so that free access, work lighting, and electrical power is available on the site.
- B. Be prepared to verify the performance of any portion of the ICS system by demonstration, listening and viewing tests, and instrumented measurements.
- C. Make additional mechanical and electrical adjustments within the scope of work and which are deemed necessary by the Owner as a result of the acceptance test.

See also Specification Section 17900: Tests, Commissioning and Project Closeout

*END OF SECTION*

**RELATED DOCUMENTS:**

The general provisions of the Contract, including General and Supplementary Conditions, and General Requirements, and Division 1 specifications that apply to the work specified in this Section.

**Part 1 – General**

**1.01 Additional Information**

A. Refer to Section 17000 for the following Part 1 General information

- 1) References
- 2) Definitions / Terms / Acronyms
- 3) Submittal Requirements
- 4) Contractor Qualifications
- 5) Manufacturer Qualifications
- 6) Bidder Qualifications
- 7) Testing Agency Qualifications
- 8) Delivery, Storage and Protection
- 9) Project conditions
- 10) Sequencing
- 11) Continuity of Service and Scheduling of Work
- 12) Protection of Work and Property
- 13) Warranty

**1.02 Products Installed but not Supplied Under This Section**

- A. All conduit and EMT required for Communications cabling pathway in/out of cross connect closets and in/out of wall cavities at the work area. EMT or Conduit for pathways shall have no more than two 90 degree bends and no continuous section over 100'.
- B. All core holes and poke through devices in the floor for the installation of Communications cabling.
- C. All core holes and EMT sleeves between floors for the routing of Communications cabling.
- D. Basket tray or ladder racking to support main pathway cable bundles.

**1.03 Backbone Cabling Description**

- A. Backbone cabling system will provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in telecommunication rooms or at the entrance facilities.

**1.04 Work Included**

- A. The Work of this Section shall consist of the labor, materials and equipment required for furnishing and installing backbone cabling as part of a complete and operating telecommunications cabling system.

- B. All items specified or included in this section shall be furnished and installed by Telecommunications Contractor, wired and connected by Telecommunications Contractor and tested by Telecommunications Contractor, unless noted otherwise. "Contractor" as used herein shall mean Telecommunications Contractor or Telecommunications Contractor's sub-contractor.
- C. All items specified or included in this section shall be furnished and installed by Electrical Contractor, wired and connected by Electrical Contractor and tested by Electrical Contractor, unless noted otherwise. "Contractor" as used herein shall mean Electrical Contractor or Electrical Contractor's sub-contractor.

**1.05 Submittals**

- A. Submit for approval in accordance with specified submittal procedures:

**1.06 Coordination**

- A. Contractor shall furnish and install the following:
  - 1) Inside plant copper backbone cables.
  - 2) Inside plant fiber optic backbone cables.
- B. Electrical Contractor shall furnish and install the following:
  - 1) Telecommunications raceways within the building as indicated and/or as required by the electrician's sub-contractor for a complete and operational system.

**Part 2 – Products**

**2.01 Multi-Pair Cables**

- A. Multi-pair Cable Specification - Inside Plant, Category 3 25 pair
  - 1) Acceptable Manufacturer: Berk-Tek.
  - 2) Cable type: Category 3 CMR.
  - 3) Jacket Material: Fire retardant PVC
  - 4) Jacket Markings: Manufacturer's identification, pair count, wire AWG, sequential footage.
  - 5) Conductors: Solid 24 AWG copper
  - 6) Twisted pairs with varying lay lengths, quantity of pairs as indicated on Drawings.
  - 7) Conductor Insulation:
    - a. CMR – Polyolefin or PVC.
  - 8) Industry standard color coding, with colored binder tape for cables greater than 25-pair.
  - 9) Jacket Color: Varies per application. See schedule on IC001.
  - 10) Electrical Characteristics: Meets TIA/EIA-568B requirements for Category 6 rated cables.



11) CMR rated cable suitable for installation in vertical risers and conduit.

## 2.02 Fiber Optic Cables

- A. Acceptable Manufacturer: Berk-Tek.
- B. Cable may be either of composite cable construction or standard cable containing single-mode fibers in one cable sheath and multi-mode fibers in a separate cable sheath. Contractor shall verify raceway fill requirements when furnishing and installing two standard cable constructions to meet composite strand count requirements.
- C. Fiber Cable Specification – Contractor shall provide 12 strand OM3 Single-Mode Fiber with SC Connectors, fiber distribution enclosures, termination panels and jumpers as required.
- D. Fiber Optic Cable Shipping Requirements
  - 1) All cabled optical fibers > 1000 meters in length shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel.
  - 2) Top and bottom ends of the cable shall be available for testing on the shipping reel.
  - 3) Both ends of the cable shall be sealed to prevent the ingress of moisture.
  - 4) Each reel shall have a weather resistant reel tag attached identifying the reel and cable. The reel tag shall include the following information:
    - a. Cable Number, Gross Weight
    - b. Shipped Cable Length in Meters, Job Order Number
    - c. Manufacturer Product Number, Customer Order Number
    - d. Date Cable was Tested, Manufacturer Order Number
    - e. Cable Length Markings, Item Number
      - i Top (inside end of cable)
      - ii Bottom (outside end of cable)
  - 5) Each cable shall be accompanied by a cable data sheet. The cable data sheet shall include the following information:
    - a. Manufacturer Cable Number, Manufacturer Product Number
    - b. Manufacturer Factory Order Number, Customer Name
    - c. Customer Purchase Order Number
    - d. Mark for Information Ordered Length
    - e. Maximum Billable Length, Actual Shipped Length
    - f. Measured Attenuation of Each Fiber Bandwidth Specification (for lengths > 1000 m)
- E. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification.

## Part 3 – Execution

### 3.01 Installation

- A. General
  - 1) All cable and associated hardware shall be placed so as to make efficient use of available space in coordination with other uses. All cable and associated hardware shall be placed so as to not impair the use or capacity of other building systems, equipment, or hardware placed by others (or existing).

- 2) Where cable is placed in ceiling areas or other non-exposed areas, cables shall be installed in cable trays or in non-continuous cable support system. Non-continuous cable supports shall be placed at random intervals no greater than 60 inches. Cables in non-continuous support systems shall be bundled using hook and loop type fasteners. Cable sag between supports shall not exceed 3 inches. Attaching wire to pipes or other mechanical items is not permitted. Cables shall not be bundled or tied in conduits, and in cable trays above ceilings.
- 3) All cabling shall be routed so as to avoid interference with any other service or system, operation, or maintenance purposes such as access boxes, network equipment, mechanical equipment access doors and covers, switches or electrical panels, and lighting fixtures. Avoid crossing areas horizontally just above or below any riser conduit. Lay and dress cables to allow other cables to enter the conduit/riser at a later time by maintaining a working distance from these openings. All cable shall be installed to allow for simple installation and removal of cables in the future.
- 4) Unless noted, all interior wiring shall be installed in raceways, Raceway Specification No. 2, one inch minimum. Wiring above accessible ceilings may be installed in cable tray and exposed on "J" hooks.
- 5) All cables not in raceways shall be riser or plenum rated.
- 6) All cables running outside the building shall be rated for outside plant installation.
- 7) Backbone cables shall be grouped separately from horizontal distribution cables. Cable for other systems shall be grouped separately from cables for telephone and data.
- 8) All inside cable shall be installed neatly above accessible ceilings using cable tray and "J" hooks supported from building structure. Do not attach to pipes, conduits, ducts, etc. Do not allow cable to rest on pipes, conduits, ducts, ceiling tiles, etc. Do not attach to wires used for supporting suspended ceilings. Do not use tie wires or bridle rings.
- 9) All wires shall be marked at all junction boxes, pull boxes, cabinets, boxes and terminations. Each cable run between terminating locations shall be one continuous cable (no splices or connections).
- 10) The Contractor shall install cable in such a manner as to prevent stretching, kinking or sharp bends. Cable damaged during installation or not passing required testing shall be removed and replaced at no additional cost to Owner.
- 11) The Contractor shall replace or rework cables showing evidence of improper handling including stretches, kinks, short radius bends, over tightened bindings, loosely twisted and over twisted pairs at terminations, and too much jacket removed.
- 12) Minimum bend radius and maximum pulling tension for all cables shall be maintained during and after installation. Install cable in accordance with manufacturer's ratings and instructions.
- 13) Cables shall not be installed near power sources or other items where interference could develop. Cables shall not be placed within 18 inches of light fixtures and within 3 feet of motors, transformers, copy machines, or solid state motor starters unless cable is installed in conduit. Contractor shall furnish and install a grounding conduit system where these minimum clearances cannot be maintained.
- 14) In telecommunications spaces, cables shall be routed as close as possible to the ceiling, floor, or corners to insure that adequate wall or backboard space is available for

current and future equipment and for cable terminations. Cables shall not be tie-wrapped to existing electrical conduit or other equipment. Minimum bend radius shall be observed.

- 15) Dress and attach cables to the backboard along the shortest possible route run square (horizontal and vertical) to the backboard. Bundle similarly routed cables together and attach by means of clamps or distribution rings. Cable dress and attachment shall minimize obstruction to future installations of equipment, backboard, or other cables.
- 16) Cables shall be neatly bundled with hook and loop type fasteners. Nylon tire wraps are not acceptable. Cables must be neatly bundled in the telecommunications spaces and at the cable service loop.
- 17) Cable service loops shall be provided at both ends of backbone cable runs.
  - a. At the telecommunications room, provide a minimum 6 foot service loop stored in the cable tray above the racks/cabinets.
  - b. At the telecommunications room, provide sufficient slack to properly dress and terminate cables at the racks and cabinets.
    - i. Provide sufficient slack so that swing gate type racks and cabinets can open fully
    - ii. Provide sufficient slack so that cables do not catch or bind at swing gate type rack or cabinet hinge and the cables do not pull taught across the hinge or edge.
  - c. A minimum 25 foot service loop shall be maintained at each building entrance and exit.
- 18) All interior fiber optic cables shall be installed in riser rated innerduct above accessible ceilings.
  - a. Innerduct shall be installed to within 12 inches of termination enclosure.
  - b. Install pull boxes, 12" x 12" minimum, as required to limit cable pulls to two 90 degree bends or 150 feet.
  - c. Innerduct shall not be kinked or tightly bent in any way.
- 19) All exterior fiber optic cables shall be installed in innerduct.
- 20) A break-away link shall be used for installation of cables with a cable-puller or winch. The break-away link shall be designed to separate at or below the recommended maximum tension of the cable being installed.
- 21) Any damage to Owner's existing cabling or existing cable owned by others, caused as a result of work performed under this scope, shall be brought to the Owner's attention and repaired or replaced within 48 hours.
- 22) Contractor shall use only cable lubricants recommended by the manufacturer for use with the specific cable construction.
- 23) Should a cable become kinked, skinned or stretched during installation, the cable shall be removed and replaced at no additional cost to the Owner. Splicing at points other than those specified will not be acceptable.

### **3.02 Copper Cable Testing**

#### **A. Unshielded Twisted Pair Testing Equipment:**

- 1) Cable tester will be NRTL certified for EIA/TIA TSB95.

- 2) The cable tester will have a wide variety of preprogrammed cable types as an integral part of its testing system and have the ability to test cables less than 6 feet (6ft.) from the test point.
- 3) All balanced twisted-pair field testers will be factory calibrated each calendar year by the field test equipment manufacturer as stipulated by the manuals provided with the field test unit. The calibration certificate will be provided for review prior to the start of testing.
- 4) Testing will be accomplished using level III or higher field tester that is loaded with the most current version of test software by the manufacturer of the test equipment.
- 5) Provide factory calibration report of field test equipment.

**B. Testing Procedures:**

- 1) Test each pair and shield of each cable for opens, shorts, grounds, and pair reversal. Correct grounded and reversed pairs. Examine open and shorted pairs to determine if problem is caused by improper termination. If termination is proper, tag bad pairs at both ends and note on termination sheets.
- 2) Test each UTP cable and passive components. Provide certification that entire installation of UTP cabling, equipment and jacks are NRTL certified meeting or exceeding a minimum of category performance specified on all four pairs of conductors.
- 3) Tests will be based on each pair of conductors and not the aggregate multiple pair results.
- 4) Test all installed cable segments end-to-end, from each telecommunications room backbone patch panel/cross-connect block panel to respective main cross connect, with a Signal Injector, Graphical Link Testing Meter and Time Domain Reflectometer (TDR) for compliance to latest TIA/EIA performance requirements, as well as NEXT, ELFEXT, structural return loss, alternating power sum, opens, shorts, continuity, cable length, and characteristic impedance.
- 5) Provide report indicating failures and what actions were taken to ensure a passing horizontal cable and its terminations. Any cable failing the certification test (Fail, Fail\* or, Pass\*) must have remedial work done to provide a full pass test result; Remediation may include retermination or replacement of the cable, which fails. No cables passing within tolerance only (Conditional Pass\*) will be accepted.

**C. Test results:**

- 1) The test results information for each link will be recorded in the memory of the field tester upon completion of the test. The tester will be capable of storing test data in either internal or external memory. The external media used will be left to the discretion of the user.
- 2) Test results saved by the tester will be transferred into a Windows based database utility that allows for maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred to the PC unaltered as well as any printed reports generated from the software application.

- 3) Optional formats of data reporting are: comma separated variable (.csv), Portable Document File (.pdf) or compatible, plain text (.txt), or hypertext markup language (.html/.htm).
- 4) Test Results will include the following:
  - a. Applicable room number of jack location (room number per Contract Documents)
  - b. Applicable Telecommunications Room number
  - c. Circuit I.D. number with corresponding jack identifier
  - d. Wire Map – will include the following:
    - i Continuity to the remote end
    - ii Shorts between any two or more conductors
    - iii Crossed pairs
    - iv Reversed pairs
    - v Split pairs
    - vi Any other miswiring
  - e. Length
  - f. Insertion Loss
  - g. Near-end Crosstalk (NEXT) Loss
  - h. PS-NEXT (Power Sum Near End Cross Talk)
  - i. ELFEXT (Equal Level Far End Cross Talk)
  - j. PS-ELFEXT (Power Sum Equal Level Far End Cross Talk)
  - k. Propagation Delay
  - l. Delay Skew
  - m. Return loss
- 5) The Owner and Engineer reserve the right to observe testing and/or randomly sample completed links for conformance to project specifications.

### 3.03 Fiber Optic Cable Testing

- A. Fiber Optic Cable Test Equipment:
  - 1) Cable tester will be NRTL certified for TIA/EIA TSB95.
  - 2) Cable testers will be Optical Power Meter and High Resolution Optical Time Domain Reflectometer (OTDR). The cable tester will be NRTL certified for compliance to latest TIA/EIA Standard 568B performance requirements at 850, 1300 and 1550 nm.
  - 3) Testers will have been calibrated at least one year prior to use on this project. Contractor to provide proof to Owner if requested.
  - 4) All testing equipment (OTDR, Light Loss, Splicer etc.) will be owned by the Contractor. Contractor must prove ownership of equipment if requested.
- B. Cable segments and links will be tested from both ends of the cable for each of the construction phases. (Verify that cable labeling matches at both ends).
- C. The system will not be considered certified until the tester has acknowledged that the performance of the physical layer of the system has been fully tested and is operational at the completion of the installation phase.
- D. Testing Procedures:
  - 1) Perform each visual and mechanical inspection and electrical test, including optional procedures, stated in NETA ATS, Section 7.25. Certify compliance with test

parameters and manufacturer's written recommendations. Test optical performance with optical power meter capable of generating light at all appropriate wavelengths.

- 2) Prior to testing, all connectors will be properly cleaned with an approved product manufactured specifically for this purpose.
- 3) Prior to beginning testing, confirm that all testing equipment is fully charged or operating on building power. If the test equipment power levels drop below 50%, recharge unit or continue testing with a different (fully charged) tester.
- 4) Initially test optical cable with a light source and power meter utilizing procedures as stated in TIA TSB-140, ANSI/TIA/EIA-526-7, ANSI/TIA/EIA-526-14A, OFSTP-14A Optical Power Loss Measurements of Installed Multi-mode Fiber Cable Plant and ANSI/TIA/EIA-526-7 Measurement of Optical Power Loss in installed Single-Mode Fiber cable plant.
- 5) Measured results will be plus/minus 1 dB of submitted loss budget calculations. If loss figures are outside this range, test cable with Optical Time Domain Reflectometer (OTDR) to determine cause of variation. Correct improper splices and replace damaged cables at no charge to the Owner.

E. Multi-Mode Fiber Optic Cables (Not Used)

F. All cables will be tested after termination using a cable certification tester that contains the test equipment manufacturer's most current version of firmware.

G. Test all fiber optic cable segments end-to-end from the fiber optic backbone patch panel in the Equipment Room to each fiber optic backbone patch panel in each Telecommunications Room.

H. Broken or faulty strands will not be accepted. Any cable not fully functional with all strands usable will be replaced at no cost to the Owner.

I. Upon completion of testing, all connectors will be capped with a product made for that specific function by the connecting hardware manufacturer to prevent the contamination of the fiber from construction debris or other foreign objects.

J. Test Results:

- 1) The test results information for each link will be recorded in the memory of the field tester upon completion of the test. The tester will be capable of storing test data in either internal or external memory. The external media used will be left to the discretion of the user.
- 2) Test results saved by the tester will be transferred into a Windows based database utility that allows for maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred to the PC unaltered as well as any printed reports generated from the software application.
- 3) The test results information for each link will be recorded in the memory of the field tester upon completion of the test. The tester will be capable of storing test data in either internal or external memory. The external media used will be left to the discretion of the user.
- 4) Test results saved by the tester will be transferred into a Windows based database utility that allows for maintenance, inspection and archiving of these test records. A

guarantee must be made that the measurement results are transferred to the PC unaltered as well as any printed reports generated from the software application.

- 5) Optional formats of data reporting are: comma separated variable (.csv), Portable Document File (.pdf) or compatible, plain text (.txt), or hypertext markup language (.html/.htm).
  - 6) Test results will include the following:
    - a. Telecommunications Room number
    - b. Location of fiber pull i.e. (Equipment Room # to Telecom Room #)
    - c. Patch panel # and location
    - d. Connector type
    - e. Distance
    - f. Wavelength tested
    - g. Technician who performed the testing
- K. The Owner and Engineer reserve the right to observe testing and/or randomly sample completed links for conformance to project specifications.

**End of Section**

SECURITY SYSTEM

Furnish and install all labor, materials and programming to provide complete and operational building security system.

The Scope of Work shall include:

- a. Access Control Contractor shall use intrusion software compatible with GE Networx systems currently being utilized by the school system. Verify with owner prior to bid.
- b. Access Control Contractor shall include (1) range testing device for each type of wireless security device, if wireless devices are provided, and verify all devices are within operational range of their controlling device. Make provision for supplying additional controllers as required to provide a fully operational system.
- c. Provide dual technology sensors with passive infrared motion and microwave sensing where indicated on the drawings, all corridors, connectors, and dining areas
- d. Receive coded signal from Fire Alarm panel (excluding "trouble status").
- e. Provide coded signal from Fire Alarm panel (excluding "trouble status") to indicate alarm status on GFAA.
- f. Communicator programmed to contact Owner's specified monitoring service.
- g. Vandal-proof controller enclosure.
- h. Security Cameras shall be Panasonic to match existing cameras. Equals as approved by owner and engineer.
  - a. Exterior – 360 Fixed Dome HDTV 1080 with HDMI (WV-S455OL)
  - b. Interior/Hallway – Multi-Direction Selectable HDTV (WV-X4170)
  - c. Vandal Resistant Dome – (WV-S2531LN)
  - d. Compact Dome – (WV-S3531L)
  - e. Pendant Kit (Where Necessary)
  - f. Wall Mount Bracket (Where Necessary)
  - g. Corner Mount Bracket (Where Necessary)
- i. Provide Video Insight recorders with 24 Terra-Byte (TB) storage and software as necessary to accommodate the quantity of inputs required on the job. Include all mounting hardware and software. Also include analog to digital encoders as necessary to accommodate the existing cameras that are to remain.

The Access Control Scope of Work shall include:

- a. All accessories, equipment, programming and installation needed for a door access control system capable of controlling the specific doors as indicated on the electrical/security/IC plans and in the architect's door hardware schedule.
- b. Multi-Class HID Readers, SE RP10 or equal. Black in color.
- c. Single multi-conductor plenum rated cable from Nodes to doors.
- d. Door Access Cable shall be Cat 6, Plenum rated and match existing in color.



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**SECTION 17700**

**ELECTRICAL**  
**SECURITY SYSTEMS**

- e. All associated door contacts and request to exit switches. Wired normally closed.
- f. A "Lock-Down" door over-ride push/pull mushroom button. Pull to activate.

Provide the following in necessary quantities to meet the requirements of the plans and schedules or a more current version of the listed equipment:

1.S2 Netbox	S2-NN-E2R-WM
2.HID Reader	S2-900PTNNEK00460-S2EC
3.Door Recessed Switch	GRI 195-12WG-W
4.Armored Door Cords	Enforcer SD-969-S18Q
5.Lock Conversion Kit	Von Duprin QEL 958003-00
6.Reg to Exit Switch	Von Duprin 0502521
7.Key Lock Power Supply	Schlage PS906-KL
8.Battery Back-Up Board	Schlage 900-BB
9.Relay Board	Schlage 900-4R

Access Control and Security System shall be installed by a S2 factory-authorized service organization with minimum five years of successful public school installation experience and licensed in N.C.

Access Control System and associated components shall be by S2 to match school system equipment or as listed above.

*END OF SECTION*

**INTERCOM SYSTEM**

Furnish and install all labor, materials and programming to provide complete and operational building Intercom system that is tied back to the existing system.

The Scope of Work shall include:

- a. Intercom Contractor shall use speaker systems matching speakers currently being utilized at the school. Verify with owner prior to bid.
- b. Intercom Contractor shall provide, install, program and test any required equipment necessary to expand the existing system to accommodate the new intercom devices in the building addition. See plans.
- c. Provide wire guard protection on any devices located in areas subject to damage. Including but not limited to Gyms, Multi-Purpose Rooms, Weight Rooms, Vocational Education Shops, etc.

Intercom system shall be installed by a factory-authorized service organization with minimum five years of successful public school installation experience and licensed in N.C.

Intercom System and associated components shall be Bogen "Quantum" to match existing school system equipment or as listed above.

*END OF SECTION*

**RELATED DOCUMENTS:**

Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

**ACCEPTANCE CRITERIA:**

The Owner will verify that all required activities have been performed in a final joint walk-through with the Contractor prior to system acceptance.

There shall be no provisions for automatic acceptance. A phased acceptance test maybe performed; however, acceptance of any phase is conditional on the acceptance of the project as a whole. Full payment will only be made after full and complete acceptance of the entire system. Acceptance shall only occur based on the written notification to the Contractor from the Owner. The following criteria must be met:

1. All cables have been tested and shown as meeting all specifications to the satisfaction of the Owner. All test reports required shall have been submitted and approved by the Owner assigned project manager.
2. All outlets are completely installed and operational in the specified locations.
3. All required patch panels are installed and operational.
4. All patch cables, cross connects, and extension cables have been delivered.
5. Final as-built documentation has been provided by the contractor.
6. Training and tools have been provided to the Owner cable management personnel in the maintenance and use of the installed cabling systems.
7. Each fiber has been tested end-to-end and a written report of signal loss and continuity has been provided.
8. All fire-stops have been installed.
9. The site is clean and neat, ready for permanent use by the Owner.

After the interior wiring system is completed and at such time as the Engineer or Owner's representative may direct, the Contractor shall conduct an operating test for approval. The tests shall be performed in the presence of the authorized representative of the Engineer and the installation shall be demonstrated to operate in accordance with the requirements of this specification. The Contractor shall furnish all instruments and personnel required for the test. The Contractor shall have sufficient tools and personnel available at the scheduled inspection to remove panel fronts, device plates, etc., as required for proper inspection of equipment, devices and wiring installation as may be required by the inspectors. Any material or workmanship which does not meet with approval of the engineer shall be promptly removed, repaired or replaced as directed, at no additional cost to the Owner.

**CLEANING AND PAINTING:**

Prior to final inspection, all equipment having factory finishes shall be thoroughly cleaned inside and outside. All damaged surfaces shall be replaced or refinished by Contractor, with paint same as original manufacturer. Engineer shall determine whether the damaged surface is to be replaced or painted.

**RECORD DRAWINGS AND DOCUMENTATION PACKAGE:**

1. Record Drawings
  - a. The Contractor shall maintain accurate records of all deviations in work as actually installed from work indicated on the drawings. On completion of the project, two (2) complete sets of marked-up prints shall be delivered to the Architect.
2. Documentation package
  - a. The successful bidder shall provide one (1) system documentation package on CD and one (1) system documentation paper copy for the installed integrated system. The documentation package shall provide the owner with a comprehensive guide for all operation and maintenance procedures for the "as installed" system. A system block diagram shall indicate the functional relationship between all sub-systems and all elements within individual sub-systems. A cabling schematic shall indicate interconnect wiring with respective numbering or other identification codes and termination block assignment. If requested, schematic drawings shall be provided for each active and passive circuit used in the completed system. All schematic drawings shall indicate the electrical value of each component and its circuit by use of standard electronic symbols.

**TRAINING:**

A. ICS System

1. Training shall include a minimum of 16 hours of user training for the end user. Training shall be provided at the school or owner designated location in a classroom setting. Training shall be divided into two (2) groups, system administrator and teacher. Training shall also include a video and/or audio format on CD-Rom and shall be formatted for use on individual CD-Rom.

B. Telephone

1. Training shall include a minimum of 8 hours of user training for the end user. Training shall be provided at the school or owner designated location in a classroom setting.

**OPERATING AND MAINTENANCE INSTRUCTIONS:**

Unless directed otherwise elsewhere in these specifications, the Contractor shall compile and bind two sets of all manufacturer's instructions and descriptive literature on all items of equipment furnished under this work. These instructions shall be delivered to the Engineer for approval prior to final inspection. Instructions shall include operating and testing procedures and a parts list of all equipment. The Contractor shall instruct the Owner's personnel in the proper operation of all systems and equipment. The front of the binder shall be titled "Technology Systems Operating and Maintenance Instructions", with name of the job and firm name of the Contractor.

**WARRANTY:**

The Contractor shall submit upon completion of the work, a warranty by his acceptance of the contract that all work installed will be free from defects in workmanship and materials. If, during the period of one year, or as otherwise specified from date of Certificate of Completion and acceptance of work, any such defects in workmanship, materials, or performance appear, the Contractor shall, without cost to the

Owner, remedy such defects within reasonable time to be specified in notice from the Architect. In default, the Owner may have such work done and charge cost to Contractor.

*END OF SECTION*  
*END OF SPECIFICATIONS*