SECTION 02815

WATER HARVESTING

PART 1 - GENERAL

1.1 Provide as indicated a rainwater harvesting system as shown on Drawing **C4.0 & C4.1 and described within this specification.** Site utilities contractor shall provide & install both Atlantis Tanks, all concrete structures, and piping & access ports outside of the building. Refer to water harvesting diagram on sheet P4.3 to indentify scope of work.

1.2 The system shall be of an approved design as fabricated by a manufacturer regularly engaged in the production of rainwater treatment equipment. All equipment and material shall be supplied in compliance with the specifications as intended for a complete and operational system. All Equipment shall be provided by one supplier who will provide installation instruction and be available for on-site installation support.

1.3 The rainwater system is intended for the purpose of collecting rainwater from roof top of the building, filtering it, storing the filtered water in storage tanks, and preparing this water for subsequent use as supply water for toilet flushing and irrigation.

1.4 Only qualified manufacturers of rain water conditioning systems shall be considered for this project. Acceptable manufacturers are Water Harvesting Solutions, Inc. (Wahaso)

PART 2 - GENERAL DESCRIPTION

2.1 The rainwater storage shall be located below grade utilizing Atlantis D-Rain Tanks with a total volume of 20,000 gallons and includes a level sensor to indicate level and volume of stored water and a sump pump to send water to a day tank located in the building.

2.2 Incoming water from roof collection shall pass through a Vortex Filter to remove debris before entering the below grade level storage tanks.

PART 3 - EQUIPMENT

3.1 CDS System

A. A CDS system shall be provided by Contech. Model Number CDS-2015-4. This system is noted as WH MH-15 in C4.0 and C4.1. Refer to C4.1 for plan view and cross section. ~~A vortex filters shall be provided to screen inlet water before entering storage tanks. The vortex filter is capable of filtering 25,000 SF of roof area. The inlet to the filter is 12" with a 6" clean water outlet and 6" outlet to storm sewer system. The filter includes a fine mesh stainless steel filter screen that will send 95% of the water to the clean water outlet and the balance with the debris to the storm sewer system outlet. Nozzles to include thermo-welded flanges. Model RH9520-06-F or approved equal.~~

3.2 Underground Storage Tanks

A. Underground Storage tanks shall be Atlantis D-Series Rain Tanks Configured in a 3-deep combined unit with each quad unit holding a Nominal volume of 120 gallons each. Total volume of storage to be 20,000 gallons. The tanks shall be manufactured using recycled polypropylene of at least 80% recycled material. Additional 1500 gallon tank shall be provided.

B. Tanks are wrapped in a 10 ounce geotextile liner with a 30 mil non-permeable outer liner. The tanks shall be installed per manufacturer's installation procedures. A factory authorized and trained installer shall be on site to oversee proper installation including excavation, liner installation, tank assembly, and installation and backfilling.

C. Atlantis D-Rain Series Tanks

3.3 Manufacturer Services

A. System to be installed by licensed Plumbing Contractor A factory authorized technician shall be available on a per diem basis to assist contractor in installation of system. Final system startup by equipment provider and training to owner shall be included in system price. (Minimum three days on-site).

B. A warranty of 12 months from startup or 18 months from delivery is included.

END OF SECTION 02815

SECTION 07262

FLUID APPLIED AIR AND VAPOR BARRIER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SECTION INCLUDES

A. Section includes: Fluid applied, air and vapor barrier in exterior wall assemblies where shown and specified.
   1. Work to include termination of barrier to all adjacent construction and to ensure barrier performance.

1.3 PERFORMANCE REQUIREMENTS

A. Material Performance:
   1. Air permeance not to exceed 0.004 cubic feet per minute per square foot under a pressure differential of 0.3 in. water (1.57 pounds per square foot) when tested according to ASTM E 2178
   2. Vapor permeance of 0.1 perms or less when tested according to ASTM E 96.
   3. VOC Content: (150 g/L) or less.

B. Assembly Performance:
   1. Air and vapor barrier assembly that has an air leakage not to exceed 0.040 cubic feet per square foot per minute under a pressure differential of 0.3 in. water (1.57 pounds per square foot) when tested in accordance with ASTM E 2357 and a vapor permeance of 0.1 perms or less when tested according to ASTM C 96:
      a. Provide an assembly capable of withstanding positive and negative combined design wind, fan and stack pressures on the envelope and transfer the load to the structure without damage or displacement.
      b. Provide an assembly that does not displace adjacent materials under full load.
      c. Provide an assembly joined in an airtight and flexible manner to the air barrier material of adjacent assemblies, allowing for the relative movement of assemblies due to thermal and moisture variations and creep, and anticipated seismic movement.

d. Provide connections to prevent air leakage and vapor migration at all adjacent construction.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's product data for each product proposed for use in the system, manufacturer's printed instructions for evaluating, preparing, and treating substrate, temperature and other limitations of installation conditions, technical data, and tested physical and performance properties.
1. Submit letter from primary materials manufacturer indicating approval of products not manufactured by primary manufacturer.
2. Include statement that materials are compatible with adjacent construction.
3. Submit reports indicating that field adhesion test on all materials to which sealants are adhered have been performed and the changes made, if required, to other approved materials, in order to achieve successful adhesion.
4. Include statement that materials/system has been tested and will comply with performance requirements of this specification.

B. Shop Drawings: Submit shop drawings showing locations and extent of air and vapor barrier assemblies and details of each condition and intersections with adjacent construction of other envelope assemblies and materials utilizing shop drawings for them, membrane counter-flashings, and details showing the following:
1. How gaps in the construction will be bridged, including inside and outside corners,
2. How materials that cover the air and vapor barrier are stripped-in to maintain air-tight condition.
3. How miscellaneous penetrations such as conduits, pipes, electric boxes, mechanical fasteners, and similar items are sealed.
4. Include VOC content of each material, and applicable legal limit in the jurisdiction of the project.
5. Include statement that materials are compatible with adjacent construction.
6. Include recommended values for field adhesion test on each substrate.

C. Samples: Submit samples, 3 by 4 inch minimum size of each material required.

D. Quality Assurance Program:

1. Submit evidence of installer current accreditation and certification under the Air Barrier Association of America's (ABAA) Quality Assurance Program. Submit certification number of installers.

2. The air barrier system shall be installed according to the methods prescribed by the Air Barrier Association of America and the manufacturer's current specification and installation guidelines.

E. Field Test Results of Mock-Up: Submit test results of air leakage test and water leakage test of mock-up in accordance with specified standards, including retesting if initial results are not satisfactory.

F. Compatibility: Submit letter from manufacturer stating that materials proposed for use are permanently chemically compatible and adhesively compatible with adjacent construction and that cleaning materials used during installation are chemically compatible with adjacent materials construction.

G. Submit three (3) fully executed copies of installer's warranty.

H. Certification: Submit a statement signed by the system manufacturer stating that manufacturers shop drawings and system details were reviewed and found to be acceptable.

I. Closeout submittal: At completion of the installation, submit a statement from the ABAA's on-site representative that the installed system complies with the system manufacturers installation details.

J. LEED Submittals:
1. Credit MR 4.1 (recycled content 10%, post-consumer + ½ pre-consumer) and 4.2 (recycled content 20%, post consumer + ½ pre-consumer): Submit product data stating the percentage of post-consumer and pre-consumer (post-industrial) recycled content by weight. Submit material cost for same.
2. Credit MR5.1 (Regional Materials, 10% Extracted, Processed & Manufactured Regionally) and Credit MR5.2 (Regional Materials, 20% Extracted, Processed & Manufactured Regionally: Submit a statement from the material manufacturer stating the distance between the place of extraction, processing, and manufacture and the project location. Regionally Extracted Materials are materials that have their source as a raw material from within a 500-mile radius of the project site.
3. Credit EQ 4.1: Manufacturers' product data for interior sealants, including printed statement of VOC content and compliance.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Currently accredited by the Air Barrier Association of America (ABAA) whose applicators are certified in accordance with the ABAA Quality Assurance Program.

B. Manufacturer: Obtain primary materials from a single manufacturer regularly engaged in manufacturing air and vapor barrier membrane as specified. Obtain secondary materials from a source acceptable to the primary materials manufacturer.

C. Accredited Laboratory Testing for Materials: Laboratory accredited by International Accreditation Service Inc. (IAS), American Association for Laboratory Accreditation (A2LA), or the Standards Council of Canada (SCC).

D. Pre-installation Conference: Conduct conference at Project site.
1. Include installers of other construction connecting to air barrier, Contractor, Architect, and Commissioner's Representative.
2. Review air barrier requirements including surface preparation, substrate condition and pretreatment, minimum substrate curing period, forecasted weather conditions, special details and sheet flashings, mockups, installation procedures,

sequence of installation, testing and inspecting procedures, and protection and repairs.

E. Field Quality Assurance: Implement the ABAA Quality Assurance Program requirements. Cooperate with ABAA inspectors and independent testing and inspection agencies engaged by the Owner (if any). Do not permit covering of the air and vapor barrier membrane until it has been inspected, tested and accepted.

F. Mock-Up: Build mock-up of barrier on exterior wall assembly where directed by Architect, minimum 10 ft. by 10ft.
1. Coordinate construction of mockup to permit inspection and testing before external insulation and cladding is installed.
2. If the Architect determines mockups do not comply with requirements, reconstruct mockups and apply barrier until mockups are approved.
3. Remove mock-up when acceptable to the Architect.

G. Mock-Up Tests for Air and Water Infiltration: Test mock-up at Contractor's expense for air and water infiltration in accordance with ASTM E 1186 (air leakage location), ASTM E 783 (air leakage quantification), and ASTM E 1105 (water penetration). Use smoke tracer to locate sources of air leakage. If deficiencies are found, reconstruct mock-up and retest until satisfactory results are obtained. Deficiencies include air leakage beyond values specified, uncontrolled water leakage, unsatisfactory workmanship.
1. Perform the air leakage tests and water penetration test of mock-up prior to installation of cladding and trim but after installation of all fasteners for cladding and trim and after installation of other penetrating elements having been flashed in.
2. Perform additional tests as necessary to achieve specified performance criteria after initial testing.

H. Mock-Up Tests for Membrane Adhesion: Test mock-up at Contractor's expense of membrane for adhesion at in accordance with ASTM D 4541 using a Type 1 pull tester except that the disk used shall be 100mm in diameter and the membrane shall be cut through to separate the material attached to the disk from the surrounding material. Perform test after curing period recommended by the manufacturer. Record mode of failure and area which failed in accordance with ASTM D 4541.
1. Modify products or procedures and retest until successful.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original packages with seals unbroken, labeled with manufacturer's name, product, date of manufacture, and directions for storage.

B. Store materials in their original undamaged packages in a clean, dry, protected location and within temperature range required by air and vapor barrier membrane manufacturer. Protect stored materials from direct sunlight.

C. Handle materials in accordance with manufacturer's recommendations.

1.7 PROJECT CONDITIONS

A. Temperature: Install air and vapor barrier within range of ambient and substrate temperatures recommended by air and vapor barrier manufacturer. Do not apply air and vapor barrier to a damp or wet substrate.

B. Field Conditions: Do not install air and vapor barrier in snow, rain, fog, or mist. Do not install air and vapor barrier when the temperature of substrate surfaces and surrounding air temperatures are below those recommended by the manufacturer.

1.8 WARRANTY

A. Installation Warranty: Provide installer's 2 year warranty from date of Substantial Completion, including all components of the air and vapor barrier assembly, against failures including loss of air tight seal, loss of watertight seal, loss of adhesion, loss of cohesion, failure to cure properly.

PART 2 - PRODUCTS

2.1 MATERIALS/SYSTEM

A. Fluid-Applied Air and Vapor Barrier: Use regular or low-temperature formulation depending on site conditions, within temperature ranges specified by manufacturer. Provide related accessories including primer, seam tape, mastic, fluid and sealant recommended by manufacturer. Subject to compliance with requirements, provide a system by one of the following:
1. Carlisle Coatings and Waterproofing; Barriseal-S
2. Grace Construction Products; Perm-A-Barrier-Liquid
3. Henry; Air-Bloc 32

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions under which air and vapor barrier assemblies will be applied, with Installer present, for compliance with requirements.
1. Verify that surfaces and conditions are suitable prior to commencing work of this section. Do not proceed with installation until unsatisfactory conditions have been corrected.
2. Do not proceed with installation until after minimum concrete curing period recommended by air and vapor barrier manufacturer.
3. Ensure that the following conditions are met:
a. Surfaces are sound, dry, even, and free of oil, grease, dirt, excess mortar or other contaminants

b. Masonry joints are flush and completely filled with mortar, and all excess mortar sitting on masonry ties has been removed.

4. Verify substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263 and take suitable measures until substrate passes moisture test.
5. Verify sealants used in sheathing are compatible with membrane proposed for use.

3.2 SURFACE PREPARATION

A. Clean, prepare, and treat substrate according to manufacturer's written instructions. Ensure clean, dust-free, and dry substrate for air and vapor barrier application. Mask off adjoining Surfaces to prevent overspray and spillage.

B. Prime substrate for application of sheet membrane transition strips as recommended by manufacturer and as follows:
1. Prime masonry, substrates with conditioning primer.
2. Prime glass-fiber surfaced gypsum sheathing an adequate number of coats to achieve required bond, with adequate drying time between coats.
3. Prime wood, metal, and painted substrates with primer.
4. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through air and vapor barrier and at protrusions.

C. Prime substrate for application of fluid-applied air and vapor barrier if recommended by manufacturer based on project conditions and as follows.

3.3 INSTALLATION

A. Air and Vapor Barrier Installation: Install transition strip materials and fluid-applied air and vapor barrier to provide continuity throughout the building envelope. Install materials in accordance with AABA recommendations and manufacturer's recommendations and as follows, unless manufacturer recommends other procedures in writing based on project conditions or particular requirements of their recommended materials:
1. Provide materials and installation to bridge and seal the following, but not limited to, air leakage pathways and gaps:
a. Connection of the wall air and vapor barrier system to the roof air and vapor barrier system.
b. Connection of the wall air and vapor barrier system to the foundation.
c. Expansion joints.
d. Openings and penetrations of window frames, storefront and curtain wall.
e. Barrier precast concrete and other envelope systems.
f. Piping, conduit, duct, and similar penetrations.
g. Masonry ties, screws, bolts and similar penetrations.
h. All other air leakage pathways in the building envelope.

2. Apply primer for transition strips at rate recommended by manufacturer. Allow primer to dry completely before transition strip application. Apply as many coats as necessary for proper adhesion.
3. Apply primer for fluid-applied air and vapor barrier as recommended by fluid-applied air and vapor barrier manufacturer. Based on manufacturer's recommendation, no primer may be required for the fluid-applied materials.
4. Apply fluid-applied air and vapor barrier using equipment and methods recommended by manufacturer, to achieve a dry film thickness as recommended by the manufacturer.
5. Apply fluid-applied air and vapor barrier and transition strips to shed water naturally without interception by a sheet edge, unless that edge is sealed with permanently flexible termination mastic.
6. Position subsequent sheets of transition strips applied above so that membrane overlaps the membrane sheet below by a minimum of 2 inches (50 mm), unless greater overlap is recommended by manufacturer. Roll into place with roller.
7. Overlap horizontally adjacent pieces of transition strips a minimum of 2 inches (50 mm), unless greater overlap is recommended by manufacturer. Roll seams with roller.
8. Seal around all penetrations with termination mastic, extruded silicone sealant, membrane counterflashing or other procedure in accordance with manufacturer's recommendations.
9. Connect air and vapor barrier in exterior wall assembly continuously to all adjacent construction and seal penetrations.
10. At changes in substrate plane, provide transition material (bead of sealant, mastic, extruded silicone sealant, membrane counterflashing or other material recommended by manufacturer) under membrane to eliminate all sharp 90 degree inside corners and to make a smooth transition from one plane to another.
11. Provide mechanically fastened non-corrosive metal sheet to span gaps in substrate plane and to make a smooth transition from one plane to the other. Membrane shall be continuously supported by substrate or as recommended by the manufacturer.
12. At through-wall flashings, provide an additional 6 inch wide strip of manufacturer's recommended membrane counterflashing to seal top of through-wall flashing to membrane or as recommended by manufacturer . Seal exposed top edge of strip with bead of mastic or as recommended by manufacturer.
13. At deflection and control joints, provide backup for the membrane to accommodate anticipated movement.
14. At expansion and seismic joints provide transition to the joint assemblies.
15. Apply a bead or trowel coat of mastic along membrane seams at reverse lapped seams, rough cuts, and as recommended by the manufacturer.
16. At end of each working day, seal top edge of membrane to substrate with termination mastic.
17. Do not allow materials to come in contact with chemically incompatible materials.
18. Do not expose membrane to sunlight longer than as recommended by the manufacturer.
19. Inspect installation prior to enclosing assembly and repair punctures, damaged areas and inadequately lapped seams with a patch of membrane lapped as recommended by manufacturer.

3.4 FIELD QUALITY CONTROL

A. Owner's Inspection: At owners option, owner will engage a qualified independent testing and inspection agency. Cooperate with Owner's inspection agency. Allow access to work areas and staging. Notify Owner's agency in writing of schedule for Work of this Section to allow sufficient time for observation. Do not cover Work of this Section until testing and inspection is accepted.

B. Air Barrier Association of America Installer Audits: Contractor shall perform and pay for ABAA installer audit certification. Allow access to work areas and staging. Do not cover Work of this Section until installer audit is accepted.

C. Testing Quantity: All testing of newly installed barrier shall be as specified by ABAA.

D. Testing Method: Testing method shall include Bubble Gun Testing per ASTM 1186; Adhesion Testing per ASTM 4541, and Thickness Testing per manufacturer. All tests shall be in accordance with ABAA.

E. All work that fails the field tests shall be re-executed until the installation passes the field testing. Modify methods of installation of subsequent work to incorporate required corrections identified by the testing process and approved by architect and commission representative and ABAA manufacturers authorized rep.

3.5 PROTECTING AND CLEANING

A. Protect air and vapor barrier assemblies from damage during application and remainder of construction period, according to manufacturer's written instructions.
   1. Coordinate with installation of materials which cover air and vapor membrane, to ensure exposure period does not exceed that recommended by the air and vapor barrier manufacturer.
   2. Do not allow materials to come in contact with chemically incompatible materials.
   3. Do not expose membrane to sunlight longer than as recommended by the manufacturer.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction and acceptable to the primary material manufacturer.

END OF SECTION

SECTION 15100

VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SUMMARY

A. Section Includes: Provide valves as indicated on drawings or inferable there from, including:

1. General common duty valves to most mechanical piping systems.
2. Special purpose valves are specified in individual piping system specifications.

1.3 SUBMITTALS

A. The Contractor and all Sub-Contractors shall be required to submit documentation to substantiate compliance with all LEED requirements for this project. Final Acceptance is dependent upon the successful submittal of all LEED documentation as required by the contract documents. In addition to the LEED submittal requirements contained within this Section, refer to Section 01352 for LEED submittal requirements and LEED project requirements.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.4 QUALITY ASSURANCE

A. Single-Source Responsibility: Comply with the requirements specified in Division 1.

B. ASME Compliance: Comply with ASME B31.9 for building services piping.

C. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set globe and gate valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gate Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Henry Pratt Company.

2. Ball Valves:
   a. Conbraco Industries, in Milwaukee
   b. Valve Company, Inc.
   c. NIBCO Inc.
   d. Crane Company

3. Plug Valves:
   a. Grinnell Corp.
   b. NIBCO Inc.
   c. Crane Company
   d. Victaulic Company of America.

4. Butterfly Valves:
   a. Henry Pratt Company
   b. Keystone Valve USA, Inc.
   c. Milwaukee Valve Company, Inc.

d. NIBCO Inc.
e. Crane Company

5. Swing and Wafer Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.

6. Strainers:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Metraflex Company.
   c. Milwaukee Valve Company, Inc.
   d. NIBCO Inc.

2.2 BASIC, COMMON FEATURES

A. Design: Rising stem or rising outside screw and yoke stems, except as specified below.

1. Nonrising stem valves may be used only where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe for isolation valves, unless otherwise indicated. Control valves sized for application.

D. 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 and smaller, except for plug valves, which shall have square heads. Furnish Owner with 1 wrench for every 10 plug valves.
3. Chain-Wheel Operators: For valves 4 inches and larger, installed 96 inches or higher above finished floor elevation.
4. Gear-Drive Operators: For quarter-turn valves 8 inches and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. Threads: ASME B1.20.1.

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

I. Lead-free Solder Joint: ASME B16.18.

1. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi cold working pressure (CWP), or Class 150, 300-psi 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.

B. Gate Valves, 3 Inches and Larger: MSS SP-70, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron handwheel.

2.4 BALL VALVES

A. Ball Valves, 4 Inches and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, full port for 1/2-inch valves and smaller and full port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:

1. Operator: Steel handwheel.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: For operator handles.

2.5 PLUG VALVES

A. Plug Valves: MSS SP-78, 175-psi CWP, ASTM A 126 cast-iron body and bonnet, cast-iron plug, Buna N, Viton, or teflon packing, flanged or grooved end connections:

1. Operator: Lever.
2. Operator: Worm and gear with handwheel, sizes 6 inches and larger.
3. Operator: Worm and gear with chain wheel, sizes 6 inches and larger, 96 inches or higher above floor.

2.6 BUTTERFLY VALVES

A. Butterfly Valves: MSS SP-67, 200-psi CWP, 150-psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, wafer, lug, or grooved style with bubble-tight shut off:

1. Disc Type: Nickel-plated ductile iron, Aluminum bronze, elastomer-coated ductile iron or epoxy-coated ductile iron.
2. Operator for Sizes 2 Inches to 6 Inches: Standard lever handle with memory stop.
3. Operator for Sizes 8 Inches to 24 Inches: Gear operator with position indicator.
4. Operator for Sizes 8 Inches and Larger, 96 Inches or Higher above Floor: Chain-wheel operator.

2.7 CHECK VALVES

A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections:

B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.

C. Wafer Check Valves: Class 125, 200-psi CWP, ASTM A 126 cast-iron body, bronze disc/plates, stainless-steel pins and springs, Buna N seals, installed between flanges.

2.8 STRAINERS

1. A. Y-PATTERN STRAINERS:Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. Blow off ball valve with hose end and cap.
5. CWP Rating: 125 psig.
6. Integral pressure and temperature taps upstream and downstream (strainer sizes 2-1/2 inch and larger

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions. Ball valves are to be installed where shown on drawings/drawing details as required by Test & Balance Contractor to successfully balance the complete system.

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. For chain-wheel operators, extend chains to 72 inches above finished floor elevation.

H. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Wafer Check Valves: Horizontal or vertical position, between flanges.

3.3 SOLDERED CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends and proximity of valve internal seat or wall to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.5 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.6 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-1/2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2-1/2 Inches and Smaller: Threaded, flanged, or grooved end.
3. Steel Pipe Sizes, 3 Inches and Larger: Grooved end or flanged.

3.7 APPLICATION SCHEDULE

A. General Application: Use gate, ball, and butterfly valves for shutoff duty; globe and butterfly for throttling duty.

B. Domestic Water Systems: 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 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.
6. Bronze Swing Check: Class 125, with rubber seat.
7. Check Valves: Class 125, swing or wafer type as indicated.

C. Heating Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze or cast-iron body to suit piping system.
2. Ball Valves: Class 150, 600-psi CWP, with stem extension and memory stop.
3. Plug Valves: Viton or teflon packing.
4. Globe Valves: Class 150, bronze or cast-iron body to suit piping system, and bronze disc.
5. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or epoxy-coated ductile iron disc; EPDM or Buna N sleeve and stem seals.

6. Bronze Swing Check: Class 150, with composition seat.
7. Check Valves: Swing or wafer type, as indicated. Swing check shall be Class 150 with bronze seat ring.

D. Chilled-Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 600-psi CWP, with stem extension and memory stop.
3. Plug Valves: Buna N packing.
4. Globe Valves: Class 125, bronze body with bronze or teflon disc; or Class 125, cast-iron body.
5. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or elastomer-coated ductile iron disc; EPDM sleeve and stem seals.
6. Check Valves: Class 125, bronze body swing check with rubber seat; Class 125, cast-iron body swing check; Class 125, cast-iron body wafer check; or Class 125, cast-iron body lift check.

3.8 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists

END OF SECTION 15100

SECTION 15183

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 DEFINITIONS

A. Not applicable.

1.4 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout (fabrication drawings) of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment. Shop drawing shall be created in AutoCAD latest edition. Copies of design drawings are not acceptable.

1. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Record Drawings: Show corrected layout (fabrication drawings) of actual refrigerant piping and specialties installation, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment. Record drawings shall be created in AutoCAD latest edition. Copies of design drawings are not acceptable. Provide both paper copy and electronic AutoCAD files.

1. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

D. Field quality-control test reports.

1. Submit written reports documenting the activities required to be performed in Part 3. These reports are to be submitted two weeks after the startup is completed.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 DELIVERY STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.7 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7.

1.8 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

B. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.9 WARRANTY

A. Written manufacturer's warranty covering parts and labor for a period of one year from substantial completion, or eighteen months from shipment, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide refrigerants by one of the following manufacturers:

1. Refrigerants:
   a. Atofina Chemicals, Inc.
   b. DuPont Company; Fluorochemicals Div.
   c. Honeywell, Inc.; Genetron Refrigerants.
   d. INEOS Fluor Americas LLC.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR or type K complying with ASTM B88 or ASTM B819.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: socket.

5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: socket.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

H. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

I. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

J. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.

5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Rated Flow: <Insert tons (kW).>
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

K. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

L. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

A. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines for Conventional Air-Conditioning Applications: Copper, Type ACR or K, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR or K, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR or K, drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 3-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR or K, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR or K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR or K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

A. Install packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.

4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.4 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Divisions 15 and 17 for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 8 if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

R. Seal penetrations through fire and smoke barriers according to Division 7.

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

U. Seal pipe penetrations through exterior walls according to Division 7 for materials and methods.

V. Identify refrigerant piping and valves according to Division 15.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 15.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

E. Support multifloor vertical runs at least at each floor.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1.
    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.8 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 15183

SECTION 15415

RAINWATER HARVESTING

PART 1 - GENERAL

1.1 Provide a rainwater harvesting system as shown on Drawing P4.3 and described within this specification and specification section 02815. The system shall be of an approved design as fabricated by a manufacturer regularly engaged in the production of rainwater treatment equipment. All equipment and material shall be supplied in compliance with the specifications as intended for a complete and operational system. All equipment shall be provided by one supplier who will provide installation instruction and be available for on-site installation support.

1.2 The rainwater system is intended for the purpose of collecting rainwater from the roof of the building, filtering it, storing the filtered water in storage tanks, and preparing this water for subsequent use as supply water for toilet flushing and irrigation.

1.3 Only qualified manufacturers of rain water conditioning systems shall be considered for this project. Acceptable manufacturers are Water Harvesting Solutions, Inc. (Wahaso).

PART 2 - GENERAL DESCRIPTION

2.1 The rainwater storage shall be located below grade utilizing tanks with a total volume of 20,000 gallons and includes a level sensor to indicate level and volume of stored water and a sump pump to send water to a day tank located in the building.

2.2 Incoming water from roof collection shall pass through a Vortex Filter to remove debris before entering the below grade level storage tanks.

2.3 A level control in the day tank shall cause the sump pump to replenish the day tank on demand.

2.4 A variable speed multi-stage pump shall provide flow to the toilet flushing system on demand as specified below. The pump discharge shall pass through a filter before being sent to the toilet distribution headers.

2.5 The system shall include a master control system with the capability of interfacing with Building Automation System as well as provide data logging capability of key water collection and use parameters.

PART 3 - EQUIPMENT

3.1 LEVEL SENSOR

A. Level sensor shall be located in below grade Atlantis tanks and shall be a 2-wire pressure transmitter 0-5 PSI. Includes stainless steel assembly and 50' of water resistant cable. Additional cable lengths available if required. Wahaso BC-5.

3.2 SUMP PUMP

A. Sump Pump shall be capable of a minimum providing 110 GPM @ 30' TDH output. Includes 2" discharge port and 1-1/2 HP 3450 RPM TEFC Motor 208 Volt/3 Phase. Includes automatic low level shutoff with level float switch assembly. Myers ME-150.

3.3 RAINWATER BOOSTER PUMP SKID (BP-1).

A. See schedule on drawing P5.1 for information and specification section 15450. Refer to drawing P4.2, detail 2 for additional details.

3.4 FINAL FILTRATION

A. Amiad Filter (115 VAC) Self Cleaning Filter shall include 50 micron filter and solenoid mounted on Wahaso Support Frame. Includes differential pressure switch with controls for automatic operation. Wahaso Model TAF-750

3.5 CHLORINATION SYSTEM

A. Water in the day tank shall be chlorinated for sanitation purposes using a dry calcium hypochlorite pellet (NSF Approved) as chlorine supply. A chlorine analyzer will monitor the level in chlorine residual (free) PPM Units. The control system allows user-selectable chlorine dose rate. Chlorination System to include Arch Chemical MM-1S Dry Chlorinator Mounted on a skid and pre-plumbed and wired. Water supply will be from NPW system. System includes 12 GPD Chlorine Dosing Pump, Injector, and chlorine sensor 4-20 mA 2 wire transmitter for direct readout in PPM of residual chlorine. Wahaso Model CL-100 or Pentair Water Pool Products Model HC-3315.

3.6 SMOOTHING INLET

A. JR Smith model number RH9530SI-08, Stainless steel smoothing inlet to reduce turbulence into cistern.

3.7 DAY TANK

A. Day Tank shall be manufactured of High Density Polyethylene. Refer to Drawing P4.1, detail 8 for additional details. Fittings for Day Tank shall be thermo-welded to tank. Norwesco model number 40023, 67" diameter x 47" tall with 16" manway. Tank to include all appropriate fittings for city water makeup air gap, discharge to booster pump, level sensor and Chlorine recirculation system. Include a sign reading "Non-Potable Water".

3.8 FLOATING SUCTION FILTER

A. JR Smith model number RH9532C-2, 2" floating filter with coarse mesh.

3.9 OVERFLOW DEVICE

A. JR Smith model number RH9530-DOK, multi-function overflow device.

3.10 MAIN CONTROL SYSTEM

A. The main control system shall include a programmable logic controller (PLC) custom programmed to control all operations of the Rainwater System including data-logging of water collection volumes and usage.

B. System shall include a color graphic touch screen interface panel custom programmed to allow access on a security basis to various parameters of the system as well as interface capability to Building Automation/Management System.

C. Control System shall be professionally wired with circuit breakers and wire terminals with all wires and terminals labeled. Full wiring Schematics and Documentation to be provided. Note that color graphic information panel can be remote located in the main building or accessed via internet interface via phone or cell modem. Manufactured by Water Harvesting Solutions, Inc. or Advanced Mechanical Systems.

3.11 MANUFACTURER SERVICES

A. System to be installed by licensed plumbing contractor. A factory authorized technician shall be available to assist contractor in installation of system. Final system startup by equipment provider and training to owner shall be included in system price. (Minimum three days on-site).

B. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective work within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

C. Initial Maintenance Service: Beginning at Substantial Completion, provide two years full maintenance service by skilled employees of rainwater harvesting Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1. Perform maintenance, including emergency callback service, during normal working hours.

END OF SECTION 15415

SECTION 15557

CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.3 DEFINITIONS – NOT APPLICABLE

1.4 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring. A laminated copy of the wiring diagram shall be affixed to the boiler near the electrical panel.

C. Source quality-control test reports.

D. Field quality-control test reports.

1. Startup Reports: Submit reports documenting the activities required to be performed in Part 3.0. These reports are to be submitted two weeks after the startup is completed.

E. Operation and Maintenance Data: Provide two operations and maintenance manuals, including boiler and burner drawings, schematics including fuel trains, general instructions for maintenance inspections, complete spare parts list and troubleshooting procedures.

F. Other Informational Submittals:

1. Provide efficiency curves, showing boiler thermal efficiency vs. return water temperature at 25%, 50%, 75% and 100% input.

G. Training Reports: Submit reports on training documenting dates and attendance.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1-2007 Compliance: Boilers shall have minimum efficiency according to Table 6.8.1F, "Gas and Oil Fired Boilers - Minimum Efficiency Requirements".

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 431, "Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards for Commercial Packaged Boilers."

E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction. Manufacturer shall provide UL-certified turndown curves for the burner.

1.6 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer’s instructions for unloading, rigging and storage of equipment.

B. Maintain manufacturer’s recommended temperature and humidity limits during storage and installation. Protect equipment from dirt, dust and other jobsite contaminants and conditions detrimental to the equipment.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.8 WARRANTY

A. Warranty Period for Fire-Tube Condensing Boilers:

1. Written manufacturer’s warranty on materials and labor for 12 months starting from date of startup, or 18 months after date of shipment, whichever is longer.
2. Leakage and Materials: 10 years from date of Substantial Completion.

3. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Patterson Kelley

B. Cleaver-Brooks

C. Neal McLain

D. Lochinvar

2.2 PERFORMANCE REQUIREMENTS

A. General: Provide documentation showing that the boiler will meet or exceed the performance criteria as described in the following subparagraphs.

B. The boiler shall operate at a minimum 90% efficiency under the following conditions:

1. 25% to 50% firing rate with 122°F return water temperature.
2. 75% firing rate with 100°F return water temperature.
3. 100% firing rate with 93°F return water temperature.

C. Verification: Submit manufacturer's published efficiency curves for submitted boiler. Efficiency curves shall be generated using the test criteria established in GAMA/Hydronics Institute publication BTS-2000, "Method to Determine Efficiency of Commercial Space Heating Boilers."

2.3 MANUFACTURED UNITS

A. Description: Factory-fabricated, assembled, and tested, condensing boiler with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: 316 stainless steel.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Burner: Modulating natural gas, forced draft. Provide a minimum turndown ratio of 10 to 1, inlet burner silencer and tight shutoff inlet air louvers.

E. The burner air louvers and a butterfly type fuel gas valve on each boiler-burner unit shall be operated simultaneously by a modutrol motor controlling both fuel and air supply by means of a characterized linkage cam assembly. The fuel air drive shall be provided with a position indicating switch which shall be inter-locked with the flame safeguard system,

to assure starting in the low fire position. Each burner shall have automatic modulation from a separate operating control. Provide in each boiler control panel a manual/automatic switch and potentiometer, for manual control of the firing rate from 15% to 100% of rated capacity over the full firing range.

F. Burner shall be equipped with a complete system of safety devices, including the electronic flame safeguard control with pre and post purge. Pre-purge shall be a full open purge of sufficient time to provide four air change ignition purges of the combustion chamber or a full 30 second duration pre-purge. All controls shall be approved by UL and meet all State of Illinois Code Part 175 requirements.

G. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates.

H. Provide emergency door shut off switch, to shut off gas supply to burner. Switch shall be complete with red and white cover plate clearly marked, “Emergency Shut Off Switch”.

I. The BOILER shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.

J. Interlock control requirements

1. The boiler manufacturer will furnish all required control interlocks between the boiler-burner and related equipment as herein specified and as follows:
   a. Contacts as required for all remote alarms.
   b. Relays for remote boiler room combustion air dampers.
   c. Contacts for remote enable/disable of boiler-burner
   d. Relay for interlock with gas booster.

K. Blower: Centrifugal fan to operate during each burner firing sequence and during prep urge and post purge the combustion chamber.

1. Motors: Comply with requirements specified in Division 15 Section "Motors."
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

L. Gas Train: ASME CSD-1, IRI.

M. Ignition: Direct-Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

N. Casing:

1. Jacket Constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Insulation: Minimum 2-inch thick, mineral-fiber insulation surrounding the heat exchanger.
4. Combustion-Air Connections: Inlet and vent duct collars.

5. Mounting base to secure boiler to concrete base.

2.4 TRIM

A. Aqua stat Controllers: Operating, firing rate, and high limit.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum NPS 3/4 hose-end ball valve, with cap and chain.

2.5 CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. All wiring to be number coded at every termination. Numbering system to be professionally printed on heat-shrink tubing at the point of connection. Wiring diagrams shall clearly indicate wiring numbers and termination points. Liquid tight shall be used throughout. Provide separate contacts for a remote alarm.
4. Factory installed Hand-Off-Automatic switch for interface to BAS. When operating in the Hand position the burner modulation will be via internal boiler controls.
5. Power disconnect switch installed in the burner control panel.
6. Provide combustion air damper relay when combustion damper is used in design
7. A ladder diagram of the boiler/burner controls laminated permanently on the inside panel door.
8. All terminals shall be uniquely identified with an alpha numeric sequence.
9. All wires shall be uniquely identified with an alpha numeric sequence.
10. A clear distinction shall be made of wiring to non-boiler vendor devices.
11. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature.
    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual -reset type (UL, CSD-1).

3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
5. Provide auxiliary contacts for monitoring from building management system.

C. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.

1. Hardwired Points: as a minimum, the controller shall be capable of monitor and control of the following points (See division 15 sequence of operation for complete control requirements):
   a. Monitoring: On/off status, common trouble alarm, low water level alarm.
   b. Control: On/off operation, control power to open combustion air damper (if damper is utilized), hot water supply temperature set-point adjustment.

2. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building management system.

2.6 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

2.7 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type AL 29-4C stainless steel or positive-pressure stainless steel 316L double-wall stack listed under UL certification number 1738, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, PVC, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.8 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Vibration Isolation: Elastomeric isolation pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 15 Section "Basic Mechanical Materials and Methods."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting: Install flue venting kit and combustion-air intake.

I. Ground equipment according to Division 16 Section "Grounding and Bonding."

J. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 CLEANING – NOT APPLICABLE

3.6 CONTRACTOR STARTUP AND REPORTING

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
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   a. Test for full capacity.
   b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.7 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Division 1 Section "Demonstration and Training."

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining chillers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 1 and 15.

END OF SECTION 15557

SECTION 15747

GROUND HEAT EXCHANGER (GHEX) HORIZONTAL PIPING DESIGN

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SUMMARY

A. The GHEX contractor shall comply with IGSHPA Standard as well as all State and local regulations pertaining to the installation.

B. The GHEX contractor shall take note: there is no guarantee to the GHEX contractor that the location of any existing utilities are exactly as indicated on the plans. Some areas may require hand digging to locate that utility. The GHEX contractor must include in the bid price, the repair of any domestic water, electrical, communication or any service line that may be damaged during the construction of this project. Any offsets required to route over or under existing lines shall also be included in the bid price of the project.

1.3 SUBMITTAL

A. Before GHEX construction begins, the GHEX contractor must submit certified and engineer stamped (licensed engineer in the State of Illinois) shop drawings to the design engineer. The shop drawings shall include all applicable manufacturer's specifications, warranties, and material safety data sheets for all materials used in the geothermal installation.

1. Submittal shall include following parameters

a. Geological formation thermal conductivity assumption with notes regarding source of assumption (i.e., recent thermal response tests in same region).
b. Geological formation thermal diffusivity assumption with notes regarding source of assumption (i.e., recent thermal response tests in same region).
c. GHEX flow test report (see part 3 below)

B. Submittal shall include signed and sealed by a qualified professional engineer licensed in the State of Illinois calculated values (all inputs and outputs) for the following parameters for the first year of system operation, and 25-year look ahead. See drawings for load in-

formation. Maximum ground temperature change over 25 year period shall not exceed 5 degrees F. Parameters shall be based on a detailed computer simulation thermal analysis of the building space conditioning equipment loading of the GHEX.

C. Product data for each field component (vaults, piping, valving, fittings, vault sump pump, identification tape, vault fan, grout, etc.). Clearly identify on each cut sheet what model number and accessories are being provided. Cross out all products not included.

D. Shop Drawings (Scale 1/8" = 1'-0"): Signed and sealed by a qualified professional engineer licensed in the state of Illinois.

1. Calculate requirements for expansion compensation for underground piping.

2. Calculate pressure drop from the building to the most hydraulically remote location in the field and back at peak design flow rate. Pressure drop shall not exceed 40 feet for field.
3. Piping layout showing expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
4. Show pipe sizes, locations, and elevations. Show piping in trench, with details showing clearances between piping, and insulation thickness.
5. Drawings shall be generated in AutoCAD latest edition.
6. The shop drawings shall include all applicable manufacturers' specifications, warranties, material cut sheets and material safety data sheets for all materials (pipe, valves, vaults, etc.) used in geothermal installation.

E. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from distribution piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

F. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and at vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing distribution piping.

G. Record Drawings (Scale 1/8" = 1'-0"):

1. Revised shop drawing showing actual installation. Provide both hard copy and electronic (AutoCAD latest edition).

1.4 QUALITY ASSURANCE

A. The GHEX contractor must have on this project a certified IGSHPA installer. The GHEX contractor performing this work must have a minimum of two years experience in performing underground closed circuit ground loop work of this project's size or larger.

B. Vertical heat exchanger (VHE) fabricators must be heat fusion certified by an authorized high density polyethylene (HDPE) pipe manufacturer's representative of the brand of pipe used. Certification must include: successful completion of a written heat fusion exam as

well as demonstrating proper heat fusion techniques under the direct supervision of the authorized HDPE pipe manufacturer's representative.

PART 2 - PRODUCTS

2.1 PIPE / TRIM

A. The pipe shall be PE3408 HDPE with a minimum cell classification of 345464C per ASTM D3035-93 and a SDR11 (160 psi) rating for u-bends and header pipe 2 inches or smaller and a minimum of DR15.5 (110 psi) for header pipe greater than 2 inch in diameter. This pipe will carry a warranty of no less than 50 years.

B. Each pipe shall be permanently indent marked with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, cell classification number and date of manufacture.

C. All piping used for VHE will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the VHE at that point. The length stamp shall read zero on one end and the actual VHE total length on the other end.

D. P/T Plugs: Shall be constructed of solid brass and have a dual seal core of Nordel, good up to 350°F for water. Plugs shall be rated zero leakage from vacuum to 1000 psig and are capable of receiving a pressure or temperature probe.

E. Butterfly Valve: See Division 15 ‘VALVES’. With exception stem shall be 416 stainless steel.

F. Ball Valves: See Division 15 ‘VALVES’ with exception stem and ball shall be stainless steel.

G. Check Valves: See Division 15 ‘VALVES’.

H. 90° Elbows: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

I. Branch and Service Saddles: Shall be molded out of high density polyethylene resins in accordance with the requirements of ASTM 3261.

J. Calibrated Balance Vales: See Division 15 ‘HYDRONIC PAIPING’.

2.2 VAULTS / MANIFOLDS

A. A test point vault will be installed between each vault and between the final vault and the building's mechanical room. The test points will be the location where the loopfield flow test, and the loopfield and the building flush out will be done. All valves and piping will be sized to match the piping of the loop field.

B. GEOTHERMAL VAULT

1. STRUCTURE: The vault shall be a composite steel and concrete structure. The vault shall be shipped from factory preformed for a concrete pour with all rein-

forcement rods manifolds, valve and piping secured in place. The interior shell shall consist of a heavy-duty steel frame and base where all joints have a continuous weld. The base frame and cross bracing shall be constructed of ¼" – 3" x 8" square steel tubing. The base cross bracing shall be spaced a maximum of 2' on center with ¼" – 3' x 3" angle iron. The sidewall and ceiling frames and all cross bracing shall be constructed of ¼" – 3' x 3" angle iron. Sidewall and ceiling cross bracing shall be spaced a maximum of 2' on center. The steel interior walls/ceiling, stainless steel floor and stainless steel sump pump pit shall be constructed of 12-gauge sheet that are specially treated with an epoxy coating on interior side and outside base. All sheet steel shall have a 2" weld every 12" at seams and support framing and a continuous weld around the base. #5 reinforcement rod shall be placed on a 12" x 12" grid spacing for sidewalls and #6 reinforcement rod shall be placed on a 12" x 12" grid spacing for the ceiling. All reinforcement rods shall be located 3" within the concrete from the interior side and welded to steel framing every 2' or less. The outer shell of the walls and ceiling shall consist of 8" thick concrete that is poured by the contractor on-site and vibrated into place. The manhole shall be constructed of ¼" sheet steel with a 3" flange that is anchored into ceiling concrete and welded to ceiling frame; all welds being continuous.

2. MANIFOLDS: High-density polyethylene (HDPE) pipe and fittings, joined together with heat fusion, shall be used for all of the vault's circuit and main header piping. All HDPE pipe and heat fused materials shall be manufactured from high-density, high molecular weight PE 3408 polyethylene compound that meets or exceeds ASTM D 3350 cell classification 345464C, and is listed by the Plastic Pipe Institute in PPI TR-4 with HDB ratings of 1600 psi (11.04 MPa) at 73°F (23°C) and 800 psi (5.52 MPa) at 140°F (60°C).

   All circuits 2" and greater shall include butterfly valves constructed of lug type/lever with cast iron body, aluminum-bronze disc, EPDM Seat, 416 stainless steel stem, rated at 200 psi. Circuits smaller than 2" and all fill ports shall be ball valves with full port opening with blow out proof stem, 600 psi non-shock cold WOG.

   Pressure/temperature ports shall be brass and have a dual seal core of Nordel, good up to 350°F for water and shall be rated zero leakage from vacuum to 1000 psig. Plug shall be capable of receiving a 1/8" pressure or temperature probe.

3. SUMP PUMP: Little Giant series 6 with mercury switch, flex connection, non-slam check valve, isolation valve and galvanized steel piping.

4. Vault shall include permanent non-corrosive ladder at each manhole. Provide two manholes per vault.

5. Vault shall include ventilating fan with duct to exterior, all required metal conduit and wiring and weather proof control switch. Single point power connection.

6. Vault shall include weather proof fluorescent light, all required metal conduit and wiring and weather proof light switch. Single point power connection.

7. See plans and details for additional requirements.

8. Based on GEOVAULT by GHP Systems Inc.

2.3 FITTINGS

A. Pipe fittings shall meet the requirements of ASTM D2683 (for socket fusion fittings) or ASTM D3261 (for butt/saddle fusion fittings). Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards and date of manufacture.

2.4 BENTONITE GROUT

A. The thermally enhanced bentonite grout used to seal the VHE shall have a minimum thermal conductivity of 0.57 Btu/hr-ft°F and a minimum of 43% solids. This grout will also have a permeability rate of less than 1X10-7cm/sec.

2.5 LOCATING TAPE

A. Locating tape must be foil backed, two inches wide or greater, with a continuous message printed every 36 inches or less reading: "CAUTION GEOTHERMAL PIPELINE BURIED BELOW". The tape shall be highly resistant to alkalis, acids, and other destructive agents found in the ground.

2.6 FIELD LOCATION

A. The four outside grid bores should be surveyed after drilling is complete, but before horizontal trenching is done.

PART 3 - EXECUTION

3.1 DRILLING

A. All drilling techniques and methods will meet local and State codes for closed-loop geothermal drilling.

B. The vertical boreholes shall be drilled to a depth that allows complete insertion of the VHE to its specified depth. The maximum borehole diameter shall be six and one-half inches nominally. If a larger diameter is required, it must be approved by the design engineer.

C. The GHEX installer must be capable of operating multiple drilling rigs at once in order to satisfy aggressive schedule requirements.

D. The drilling equipment shall be able to drill through consolidated bedrock formations.

E. All drill casing shall be steel permanently installed and sealed into bedrock.

3.2 DRILLING SPOILS AND PROCESS FLUIDS

A. There shall be adequate drilling spoils management equipment on site while drilling to handle predictable spoils and drilling fluid volumes. All drilling spoils and fluids shall be contained within piping systems and construction dumpsters or settling tanks in order to maintain a clean and safe work site.

B. Drilling spoils and excavated material not recycled on site shall be hauled away by a licensed waste hauler according to local regulations.

3.3 Water used or brought to the surface during drilling operations shall not run-off the site or be discharged to sewers or storm drains until filtered using filtration equipment capable of a minimum separation of 15 microns d 50 cut.

3.4 U-BEND PIPE ASSEMBLY

A. U-bend assembly shall have integrated concrete and HDPE weight for overcoming buoyancy and for protection of u-bend fitting during installation. If necessary, an iron (sinker) bar can be attached at the base of each u-bend to overcome buoyancy. This iron

bar will have all sharp edges adequately taped to avoid scarring and/or cutting of the polyethylene pipe. No driving rod that is pulled out after u-bend insertion will be allowed. The entire u-bend pipe assembly is inserted to the specified depth in the borehole.

3.5 GROUTING PROCEDURE

A. The VHE is to be grouted from the bottom up, in a continuous fashion, using an HDPE tremie pipe. The tremie pipe will be pulled out during the grouting procedure maintaining the pipe's end just below grout level within the borehole. All State regulations will be met for borehole grouting of the VHE. The VHE shall be pressurized and capped during the grouting procedure and for 4 hours afterwards as the grout sets up.

3.6 HEAT FUSION and ELECTRO-FUSION PIPE JOINING

A. All underground pipe joining will be heat fused or electro-fused by socket, butt or saddle (sidewall) fusion in accordance to ASTM D2610, ASTM D2683 and the manufacturer's heat fusion or electro-fusion specifications. The operator shall be heat fusion or electro-fusion certified and experienced in executing quality fusion joints.

3.7 EXCAVATION AND BACKFILLING FOR PIPING

A. The GHEX contractor shall do all excavating, backfilling, shoring, bailing and pumping for the installation of his work and perform necessary grading to prevent surface water from flowing into trenches or other excavations. Sewer lines shall not be used for draining trenches. All pipe and conduit ends shall be kept sealed and lines left clean and unobstructed during construction. Only material suitable for backfilling shall be piled a sufficient distance from banks of trenches to avoid overloading. Unsuitable backfill material shall be removed as directed by the design engineer.

B. A layer of sand shall be installed to a minimum six inch depth around all HDPE piping, unless noted otherwise.

C. Sheathing and shoring shall be done as necessary for protection of work and personnel safety. Unless otherwise indicated, excavation shall be open cut except for short sections. The GHEX contractor shall install geothermal locating tape at least 18 inches above all horizontal/header piping.

D. Prior to trenching, the GHEX contractor shall be responsible for reviewing with the general contractor the location of underground utilities. Existing utility lines uncovered during excavation shall be protected from damage during excavation and backfilling.

3.8 PIPE INSTALLATION

A. Reasonable care shall be taken to ensure that the GHEX pipe is not crushed, kinked, or cut. Should any pipe be damaged, the damaged section shall be cut out and the pipe reconnected by heat fusion.

B. The VHEs must be connected as indicated on the plans. The header design accounts for balanced flow as well as flushing and purging flow rates. No variations can be made in the circuit hookup or the pipe sizes that are indicated without approval from the design engineer. The minimum bend radius for each pipe size shall be 25 times the nominal pipe

diameter or the pipe manufacturer's recommendations, whichever is greater. The depth of all headers and supply and return piping is indicated on the plans and must be maintained.

C. Layout of geothermal field and sizing of piping to/from the building shall be such that at maximum flow, the pressure drop of the entire field as measured in the fire pump room 126 shall not exceed 40 feet total dynamic head.

3.9 TESTING AND CLEANING

A. Cleaning

1. During installation, all debris, and small animals shall be kept out of the pipe. Ends of the HDPE pipe shall be sealed until the pipe is joined to the circuits.

B. Flushing and purging

1. Piping shall be flushed and purged with a water velocity of two feet per second. The lines shall be left filled with clean water and then pressure tested. If connection to the manifold is not immediate, piping must be capped. The GHEX contractor must coordinate with the mechanical contractor on propylene glycol antifreeze installation. The quantity of 20% propylene glycol associated with the field and underground piping shall be provided by the mechanical contractor. Propylene glycol antifreeze will not be added to the loopfield until after the loofield has passed the GHEX Flow Test.

C. GHEX Flow Test

1. A test of the GHEX will be conducted after all piping has been flushed and purged. The test will be done from (the) (each) loopfield test point vault.
2. The PBC, (the) (each) Commissioning Agent and (the) (each) Mechanical Engineer will be notified 3 workdays in advance of the test.
3. The Loopfield Flow Test will consist of a flow rate demonstration showing that the loopfield can achieve 105% of the required gallon per minute flow rate to (the) (each) building as specified for (the) (each) building per (the) (each) Mechanical Engineer's design requirements(s). The flow will be monitored for 30 minutes.
4. The report will note the following information:

    a. Location of the loopfield
    b. Date and time of the test
    c. Person conducting the test
    d. Pump and monitoring equipment used at (the) (each) test point
    e. Calibration certificate for the flow rate monitoring device(s)
    f. Required flow rate to (the) (each) building
    g. The lowest flow rate observed to/from each vault, the building and the associated pressure drop across at each vault and across the entire field at total flow.
    h. Witnesses present at the test
    i. Temperature of the loopfield water
    j. Signed and certified by the person conducting the test

D. Pressure testing

1. At a minimum, the following pressure tests shall be conducted during installation. If leaks are observed, they must be fixed prior to sign off.

   a. Prior to backfill, all horizontal piping smaller than 4" in diameter shall be filled with water, purged of air and pressurized to 100 psi. A careful visual examination of the piping with a witness present is required. If no leaks are observed a pressure test log form must be signed before the backfill process may commence.

   b. Prior to completion, the entire GHEX field shall undergo an expansion based pressure tested in compliance with the recommended hydrostatic pressure test in Chapter 2 of the Plastic Pipe Institute's *Handbook of Polyethylene Pipe, Second Edition.*

      1) Hydrostatic pressure leak tests of PE pressure piping systems should be conducted in accordance with ASTM F 2164(8). The preferred hydrostatic testing liquid is clean water. Other non-hazardous liquids may be acceptable.
      2) Restraint –The pipeline test section must be restrained against movement in the event of catastrophic failure. Joints may be exposed for leakage examination provided that restraint is maintained.
      3) The testing equipment capacity and the pipeline test section should be such that the test section can be pressurized and examined for leaks within test duration time limits. Lower capacity testing and pressurizing equipment may require a shorter test section.
      4) Test equipment and the pipeline test section should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.
      5) For pressure piping systems where test pressure limiting components or devices have been isolated, or removed, or are not present in the test section, the maximum allowable test pressure for a leak test duration of 8 hours or less is 1.5 times the system design pressure at the lowest elevation in the section under test. If lower pressure rated components cannot be removed or isolated from the test section, the maximum test pressure is the pressure rating of the lowest pressure rated component that cannot be isolated from the test section. Test pressure is temperature dependent and must be reduced at elevated temperatures.
      6) The test section should be completely filled with the test liquid, taking care to bleed off any trapped air. Venting at high points may be required to purge air pockets while the test section is filling. Venting may be provided by bleed valves or equipment vents.
      7) The test procedure consists of initial expansion, and test phases. For the initial expansion phase, the test section is pressurized to

test pressure and make-up test liquid is added as required to maintain maximum test pressure for four (4) hours. For the test phase, the test pressure is reduced by 10 psi. This is the target test pressure. If the pressure remains steady (within 5% of the target test pressure) for an hour, leakage is not indicated.

8) If leaks are discovered, depressurize the test section before repairing leaks. Correctly made fusion joints do not leak. Leakage at a butt fusion joint may indicate imminent catastrophic rupture. Depressurize the test section immediately if butt fusion leakage is discovered. Leaks at fusion joints require the fusion joint to be cut out and redone.

9) If the pressure leak test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized and repairs made. Allow the test section to remain depressurized for at least eight (8) hours before retesting.

END OF SECTION 15747

SECTION 16721

ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 DESCRIPTION

A. This Section specifies equipment or systems, which will be commissioned as part of the construction process. The contractor will be required to provide documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel. The Commissioning Authority will work in cooperation with the contractor to ensure compliance. Final Acceptance is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Sections 01810 and 16995 for detailed commissioning requirements.

B. Furnish and install a complete operating Class II Fire Detection and Alarm System, including:

1. Fire alarm control panel
2. Sprinkler supervisory alarm panel
3. Fire alarm control panel annunciator
4. Sprinkler supervisory alarm annunciator
5. City Fire Alarm Box
6. Bells
7. Heat and Smoke detectors
8. Manual pull-stations
9. Audible alarm devices
10. Visual alarm (strobe) devices
11. Connections to water flow switches
12. Connections to sprinkler valve tamper switches
13. Pre-signal alarms as indicated on drawings
14. Connections to/from Elevator controller Fire pumps, ATSs

C. Related requirements specified elsewhere:

1. Water flow switches, valve tamper switches.
2. Fire pumps

1.3 REFERENCE STANDARDS

A. The work is subject to applicable portions of the following standards:

1. NFPA 72
2. City of Chicago Building Code

1.4 SUBMITTALS

A. The Contractor and all Sub-Contractors shall be required to submit documentation to substantiate compliance with all LEED requirements for this project. Final Acceptance is dependent upon the successful submittal of all LEED documentation as required by the contract documents. In addition to the LEED submittal requirements contained within this Section, refer to Section 01352 for LEED submittal requirements and LEED project requirements

B. Make submittals as required by Section 16700.

C. The contractor shall provide all submittal information as required by the City of Chicago for fire alarm system permits. This shall include but not be limited to all preliminary drawings, diagrams, zone schedules, riser diagrams, equipment catalog sheets and system specifications. **This shall also include the fire alarm system Sequence of Operation.** All information shall comply with the submittal requirements of the City of Chicago Bureau of Fire Prevention Guidelines.

D. The contractor shall be responsible for submission of all documentation required for final City of Chicago approval for occupancy of the building, which shall include but not be limited to items defined in Paragraph B plus point to point fire alarm drawings, conduit size and wire count (type and number). All information shall comply with the submittal requirements of the City of Chicago Bureau of Fire Prevention Guidelines.

E. Report of manufacturer start-up procedures.

1.5 FIRE ALARM FUNCTION

A. General:

1. The electrical contractor shall obtain from Division 15 a description of the sequence of operation for the ventilation system in fire mode. The system shall be automatically activated by area smoke detectors, sprinkler flow switches, and fire alarm pull stations as well as manually controlled by the fireman from the smoke control panel.
2. Duct smoke detectors are to be provided and installed by Division 15. Note: Activation of the duct detectors shall not cause the automated calling of the Fire Department. Duct smoke detectors shall not be wired back to the fire alarm panel.
3. The electrical contractor shall obtain from Division 11 a description of the sequence of operation for the security system requirements. The fire alarm system shall automatically activate the Delayed Egress System in order to release normally secure doors upon fire alarm. Provide the necessary wiring to complete this

function.

4. Provide connection from Fire Alarm panel to elevator controller to activate elevator recall, in accordance with NFPA 72 and Chicago Elevator Code.

B. The actuation of any manual station, automatic heat or smoke detector (except duct detectors), or sprinkler flow switch shall automatically cause the following functions:

1. Visually indicate zone at the Fire Alarm Control Panel and at the remote annunciator(s).
2. Activate all audible indicating appliances when general alarm key switch is turned to ON.
3. Activate all visual indicating appliances when general alarm key switch is turned to ON.
4. Unlock all stairway doors or other delayed egress doors.
5. Provide signal to Building Energy Management System (by Division 15).
6. Release electromagnetic door holders and activate prisoner holding area isolation shutters.
7. Transmit a signal to the central monitoring station.
8. Shut off audio systems such as P.A.., sirens, etc.

C. Activation of an elevator equipment room smoke detector or elevator lobby detector, shall initiate elevator recall and control in accordance with NFPA 72.

D. In addition to the above, the following functions shall be monitored:

1. Fire pump status indication including power loss, phase reversal and pump run
2. Emergency power generator status indication.
3. Sprinkler valve supervisory switches. Each valve supervisory switch shall be on circuit separate and distinct from any other supervisory switch or flow switch.

E. All signals shall continue to be activated until all initiating devices have been restored to normal condition, the fire alarm control panel has been reset, and the general alarm key switch has been turned off.

F. The manual stations, detectors, flow switches, tamper switches, and air handling detection devices shall be identified by zoning.

G. The actuation of a valve supervisory switch shall cause a supervisory trouble signal.

H. Interface the pre-action control system provided for data processing room with the main fire alarm system to receive the alarm.

I. **Interface Fire Alarm Control Panel to the Building Automation System for monitoring of alarm, supervisory and trouble signals. Refer to IAS Specification Sections 17800's.**

1.6 SPRINKLER VALVE TAMPER SWITCH FUNCTIONS

A. The activation of any tamper switch shall cause the following functions:

1. Indicate at the sprinkler supervisory alarm panel and associated annunciator.

2. Sound bell at the supervisory alarm panel.

1.7 STANDBY POWER

A. Upon failure of normal and/or emergency power, standby power shall be provided for the entire system by means of battery power as follows:

1. Direct battery system and charger with battery capacity as follows:
   a. NFPA 72
   b. 24 hours standby
   c. 5 minutes of alarm

PART 2 - PRODUCTS

2.1 FIRE ALARM CONTROL PANEL (FCP)

A. The fire alarm control panel shall be modular, of dead-front construction using solid state components to operate the system. Alarm initiating circuits shall meet National Electrical Code requirements for limited energy applications and function with up to 100 Ohms resistance in the alarm initiating device and its associated wiring. The control unit shall contain an internal audible signal with audible acknowledge switch, system reset switch, lamp test switch, audible silence switch, an auxiliary master box disconnect switch. Control unit shall be double-supervised so that a trouble signal shall sound in the event of loss of either operating or supervising power. Two light-emitting diodes (LED's) shall be installed and shall remain illuminated to indicate both operating and supervisory power are energized. Trouble audible acknowledge switches shall be furnished, each with its associated LED, so that indication of trouble on alarm initiating circuits, alarm indicating circuits and supervisory circuits shall initiate a control panel audible device and be silenced independently.

B. The silencing of a trouble condition in any zone shall not prevent the resounding of the control panel audible device in the event of a subsequent trouble condition in other circuits. When trouble conditions are restored to normal the audible acknowledge switch shall not require restoration to normal.

C. Each zone shall have separate supervised zone trouble and zone alarm indication.

D. The initial receipt of a zone alarm shall cause its associated zone alarm lamp to flash until the system acknowledge switch is actuated which shall cause the alarm zone lamp to be lit continuously. In the event subsequent new alarm are received, their respective lamps shall likewise flash until acknowledged. When the alarm initiating device circuit is restored to normal the corresponding zone trouble lamp shall flash to indicate the alarm zone can be reset.

E. All zone associated alarm and trouble LED's on the control panel shall be supervised so that an open or shorted LED will indicate a trouble condition.

F. Provide city tie control panel as a separate section of the main fire alarm control panel. This unit shall contain key operated cut-off switch, trouble bell, trouble lamp, and all necessary apparatus to transmit signal intelligence from the local system to the city network system.

An externally mounted trouble bell, lamp, and silencing switch shall be furnished with this unit. Provide two telephone lines to the fire alarm control panel. Provide a list from the City on who to notify via two phone lines if an emergency condition is reported at the fire alarm control panel.

G. The control panel audible device shall sound continuously and the common trouble LED shall light when a trouble occurs. When the acknowledge switch is activated, the control panel audible device silenced LED shall light and the common trouble LED shall be lit continuously until the trouble has cleared. To aid in trouble shooting, means shall be provided to individually indicate all sources of trouble.

H. In the event of total power loss and restoration, the status of the initiating and indicating devices shall remain unchanged.

I. Each initiating circuit shall have (1) N.O. auxiliary contact pre-wired to marked terminal blocks.

J. All sections of the fire alarm control panel shall be behind locked doors.

K. The control panel shall be capable of future expansion and shall provide five active signal initiating zones and provisions for the future addition of five zones.

L. Each circuit shall include individual supervisory and alarm relays and/or circuitry so that a fault condition in any circuit will not prevent the proper operation of any other circuit. These circuits shall be identified by a lettered nameplate showing the zone designation or function. The nameplate shall be a standard product of the manufacturer designed to enhance the appearance of the face-plate. It shall not be lettered with embossed tape.

M. All signal initiating circuits will automatically lock in until the detection device has been restored to normal and the control panel has been manually reset.

N. The common control section of the fire alarm panel shall reset the system, silence the trouble buzzer and/or the audible alarm, disconnect the municipal box from the control panel, and provide a fire drill switch to test the audible devices without tripping the city box. A reverse polarity transmitter and a local energy circuit shall be available.

O. Plug-in connectors shall be used to inter-connect mother boards. All mother boards shall be identical and shall be capable of accepting all modules introduced to its assembly.

P. All modules shall be supervised and removal of any module shall cause a trouble condition in the panel. The control panel shall have a power supply with sufficient power output to operate the system. Auxiliary power packs shall be supervised.

2.2 REMOTE ANNUNCIATOR PANELS - LEGEND TYPE

A. Annunciators shall be located within 20 feet of the main entrance.

B. A separate indicator shall be provided for each zone.

C. Indications on the panel shall be continuous until manually reset.

D. The annunciater shall be back-lit type.

E. The Fire Alarm annunciator panel shall be powered from the Fire Alarm Control Panel. The sprinkler supervisory alarm annunciator panel shall be powered from the sprinkler supervisory alarm panel.

F. The engraving on the legends shall agree with the final designations and nomenclature for the project.

G. Enclosure shall be flush or surface mounted as required. Locate at Fire Department's Entry.

H. Finish of enclosure shall be red and shall meet with approval of the Chicago Fire Prevention Bureau.

I. Additional valve supervisory switch panels shall be provided.

J. Comply with all requirements of the City of Chicago Building Code, for annunciators – 9 (15-16-1400).

2.3 ALARM INITIATING DEVICES

A. Manual Fire Alarm Stations:

1. The stations shall have a durable red finish with white raised letters, and shall be of the break-glass rod type. Hardware and backbox shall be of metal construction.
2. Surface mounted stations shall mount on a red finish backbox.
3. Flush mounted stations shall mount directly on a standard electrical outlet box.
4. The pull lever of the station shall remain in the actuated position until restored to normal by means of a special key or tool.
5. The station shall be activated by dual action.

B. Water flow sprinkler valve tamper switches:

1. Sprinkler valve tamper switches and water flow switches shall be furnished and installed under Division 13 and wired under this Section.

C. Automatic Heat Detectors:

1. Rate of Rise and Fixed Temperature:
   a. Automatic heat detectors shall be the combination rate-of-rise and fixed temperature type - rated at 135F. for areas where ambient temperatures do not exceed 100F. and rated at 200F. for areas where ambient temperatures exceed 100F. but not 150F.
   b. The rate-of-rise element shall consist of an air chamber, a flexible metal diaphragm, and a factory-calibrated moistureproof, trouble-free vent and shall operate when the rate of temperature rise exceeds 15F. per minute.
   c. The fixed temperature element shall consist of a heat collector held by standard sprinkler fusible solder.
   d. Detectors shall have a smooth ceiling rating of 2500 square feet and an

electrical rating of 1 amp at 6 to 28 volts D.C. (fixed temperature detectors shall have the same temperature and electrical ratings as combination thermostats but a smooth ceiling rating of 625 square feet).

2. Rate Anticipation Fixed Temperature
   a. Automatic heat detectors shall be Rate-Anticipation Fixed Temperature type without noticeable thermal lag; and designed to anticipate and compensate for temperature rate-of-rise conditions without reliance on any barometric principle so as not to actuate prematurely on a fast heat rise, or lag more than 5% above rating with any type of heat rise.
   b. Detectors rated at 135 degrees F. shall be used for ordinary areas where normal ceiling temperatures do not exceed 100 degrees F., or at 200 degrees F. for intermediate areas where ceiling temperatures may normally be expected to exceed 100 degrees F. but not 150 degrees F.
   c. Detectors shall have a smooth ceiling UL rating of 50' x 50' (2,500 sq. ft.).

D. Automatic Smoke Detectors:

1. Ionization - Type Smoke Detectors:
   a. Ionization smoke detectors shall consist of a measuring chamber and a reference chamber.
   b. All electronic circuits shall be solid state devices and hermetically sealed to prevent dust, dirt or humidity from interfering with their operation.
   c. All circuitry shall be protected against electrical transients (RFI) and electromagnetic interference (EMI).
   d. The response sensitivity of each detector shall be field adjustable to one of two predetermined (factory calibrated) levels. It shall be possible to test the sensitivity of a detector in the field.
   e. The response (activation) of a detector shall be clearly visible from the outside by a red light emitting diode.
   f. A built-in wire mesh shall prevent entry of insects into the measuring chamber.
   g. The detector shall connect to the local control unit via a fully supervised circuit:
      1) Two-wire devices.

   h. The detector shall provide the following electrical characteristics:

1)	Ambient Temperature	0C to 38C (32F to 160F)
2)	Relative Humidity	Max. 95% RH continuous, without condensation
3)	Ambient Air Velocity	Max. 2700 FPM
4)	Operating Voltage	24V Nominal (16 to 26V)
5)	Quiescent Current	
6)	Draw	60 Microamps Maximum
7)	Current in Alarm	
8)	State	100 mA Maximum
9)	Applicable Listings	U.L. 268
10)	Smoke Sensitivity	
11)	(Cotton Wick):	1% Ft. Nominal

2. Photoelectric Type (Light Scattering) Smoke Detectors:
   a. The photoelectric detection chamber shall operate on the light scattering principle. An infrared light source shall emit a pulsed, forward scattering, beam center focused upon a receiving cell. This arrangement shall provide stable detection for smoke particles ranging between 0.1 and 1.0 microns in diameter.
   b. Smoke density in the chamber shall be measured by a symmetrical optical system.
   c. All electronic circuits shall be solid state devices and hermetically sealed to prevent dust, dirt or humidity from interfering with their operation. All circuitry shall be protected against electrical transients (RFI) and electromagnetic interference (EMI).
   d. The response sensitivity of each photoelectric detector shall be factory calibrated and permanently set. It shall be possible to test the sensitivity of a detector in the field.
   e. The response (activation) of a detector shall be clearly visible from the outside by a red light emitting diode (LED).
   f. A wire mesh shall prevent entry of insects into the measuring chamber while not inhibiting the entry of slow moving smoke.
   g. The detector shall connect to the control unit via a fully supervised circuit:
      1) Two-wire devices.

   h. The smoke sensitivity of the photoelectric detector shall be 3.2%. The detector shall include an integration circuit for deceptive alarm suppression and an adjustable smoke entry window.
   i. The detector shall provide the following electrical characteristics

1)	Ambient Temperature	-25C to 75C (-16F to 167F)
2)	Relative Humidity	Max. 95% RH continuous, without condensation
3)	Operating Voltage	24Vdc Nominal (16-30V)
4)	Quiescent Current	
5)	Draw	90 Microamps Maximum
6)	Current in Alarm	
7)	State	100 mA Maximum
8)	Applicable Listings	U.L. 268
9)	Smoke Sensitivity	
10)	(Cotton Wick):	3.2% Ft. Nominal
11)	Response Integration Time	7 Seconds

3. Standard Detector Bases:
   a. The specified smoke detectors shall fit into a common type detector base.
   b. Once a base has been installed, it shall be possible to insert, remove and exchange different types of detectors.
   c. The standard base shall be equipped with wiring terminals.
   d. The following shall be provided with detector.
      1) Auxiliary relay.
      2) Integral thermal sensor.
      3) Integral audible alarm indicator.

   e. All standard bases shall be supplied with a removable shorting plug to

protect the contact area during installation and during the construction phase of the building. It must allow the check-out and verification of the zone wiring before insertion of any detectors.

f. The standard base shall feature built-in mechanisms which allow mechanical locking of an installed detector head, and prevent unauthorized removal or tampering.

2.4 ALARM INDICATING DEVICES

A. Horn Unit:

1. Operation shall be from 24 VDC supervised parallel indicating circuits.
2. The horn assembly shall be housed in a die-cast enclosure.
3. Minimum sound pressure level shall be 92 DB on axis at 10 feet.
4. The unit shall be U.L. listed for use in fire protective systems.

B. Strobe Unit:

1. Strobe unit shall consist of a visual alarm strobe device, wall mounted, housed in a metal backbox. They shall be constructed for safe use in boiler rooms, kitchens and all indoor locations in ambient conditions ranging from 30oF. to 150oF.
2. The visual device shall be a high intensity Xenon flasher with a minimum intensity of 75 candela.
3. The lens shall be white with red lettering on the housing for "FIRE". Orientation of lettering on housing shall be such that upright letters are provided when unit is installed.
4. The unit shall flash at a frequency of 1 to 3 Hz with a maximum pulse duration of .2 seconds and maximum duty cycle of 40%.
5. Visual devices shall be activated, by zone, when the associated audible indicating zone is activated at the Fire Alarm Control Panel.
6. Power for visual devices shall be from separate, supervised 24 VDC indicating circuits. (Zoned for each floor and stairwell. Multiple circuits will be required to accommodate distance and loading.)
7. The unit shall be U.L. listed for use in fire protective systems.
8. Units shall be flush mounted in finished areas and surface mounted in unfinished areas and shall be provided with appropriate back boxes.
9. Units mounted in plenum areas or ceilings shall include plenum box and mounting hardware.
10. Manufacturer:
11. Gentex - GXS - 4 HWR
12. Space Age - V33-BL-SFXC-TF24D

C. Alarm Bell:

1. Alarm bells shall be of the underdome vibrating type with gongs no smaller than 8" in diameter with red finish.
2. Bells shall be polarized and operate at 24 volt. D.C. bells shall be suitable for surface or semi-flush mounting. Surface mount shall be weatherproof.
3. Semi-flush shall mount to any standard 4 inch square, 4 inch octagon or single-gang box with a maximum projection of 2-1/2".

D. Alarm Chime:

1. Chimes shall be installed only in a vertical position at each location.
2. Chimes shall be of the single stroke solenoid type designed for operation on 24 volt D.C.
3. The chime mechanism shall be completely enclosed by a removable cover to prevent dust accumulation and mechanical damage.
4. Chime solenoids shall be of low current design with a maximum power requirement of 6 watts. Chimes shall be polarized.

2.5 ELECTRICALLY-OPERATED DOORS (WHERE SHOWN - SEE DOOR SCHEDULE)

A. Electrically-operated doors shall be interlocked with the fire alarm control panel so that in case of fire, such doors shall be released into the closed position. Refer to architectural drawings for door schedule.

B. Door Lock Release:

1. Provide a yellow light for each door lock circuit which will illuminate when the power for the door lock has been interrupted.

C. Door holders shall be the fail safe electromagnetic type, brushed aluminum finish. Coordinate door holders as to location, voltage and ampere drain. Each circuit shall have its own fuses, disconnect switch and pilot light.

1. Provide control switches with lights for maintaining power to door holders during fire alarm test.
2. Door holders are to be provided by Division 16 unless otherwise noted on the architectural drawings and specifications.
3. Provide one system smoke detector on each side of smoke door within 5 feet.

2.6 EQUIPMENT AND SERVICE

A. Equipment shall be as manufactured by a firm who has been actively manufacturing fire alarm system for a minium of (10) years. Manufactures not meeting this requirement will no be considered.

B. Equipment manufacturer shall maintain factory trained personnel within 20 miles of the project site.

2.7 MANUFACTURERS

A. Simplex

B Notifier

C. Cerberus Pyrotronics, Division of Siemens

2.8 SYSTEM WIRING

A. Class 2 City of Chicago wiring system shall be provided.

B. Wiring shall be color coded as follows:

1. Signal circuits: No. 14 AWG black.
2. Station and/or detector box circuit: No. 14 AWG red and No. 14 AWG blue.

C. Wiring shall be numbered.

D. Wiring shall be in complete accordance with the manufacturer's wiring instructions.

2.9 IDENTIFICATION

A. Fire alarm terminal and junction locations shall be identified in accordance with NFPA 70, Article 760. Junction and terminal boxes shall be painted red and stenciled "Fire Alarm", preventing unintentional interference with the signaling circuits during testing, servicing, and additional modifications to the system.

2.10 SPARE EQUIPMENT

A. Furnish the following spare equipment to the Owner at the completion of the project:

1. Two detectors.
2. Twelve glass rods/plates for manual pull stations.
3. Two spare fuses for each size (ampere rating) fuse furnished in the control panel.
4. One spare zone card (P.C.B.).
5. Five spare keys of each type.
6. The above equipment shall be installed in a flush cabinet, red in color with 1/4" high white lettering, "Spare Fire Alarm Equipment", silk screened on cabinet door. This cabinet shall be mounted adjacent to the main fire alarm control panel.

PART 3 - EXECUTION

3.1 WIRING

A. Wiring shall be installed in raceways. For Class 2 City of Chicago wiring, provide Class B wiring. Install all wiring of alarm and detection systems as required for alarm, indication, and control functions specified. No portion of wiring shall be considered excluded from the Contract. Wire water flow switches and valve tamper switches in separate raceways.

B. Contractor shall provide protection for all smoke detectors from construction debris.

3.2 MANUFACTURER'S SERVICES

A. Supervision of installation shall be provided by trained service technician from manufacturer of fire alarm equipment.

B. Technician shall be US certified and have minimum of 2 years of service experience in fire alarm industry.

C. Technician's name shall appear on equipment submittals and letter of certification from fire alarm manufacturer shall be sent to project engineer.

D. Manufacturer's service technician shall be responsible for following items:

1. Pre-installation visit to job site to review equipment submittals and verify method by which system shall be wired.
2. Make periodic job site visits to verify installation and wiring of system.
3. Upon completion of wiring, final connections shall be made under supervision of technician.
4. At time of final checkout, technician shall give operational instructions to Owner and/or his representative.
5. Job site visits shall be dated and documented in writing and signed by electrical contractor.
6. Discrepancy shall be noted on document and copy kept in system job folder, which shall be available to project engineer any time during project.

3.3 TESTING

A. Manufacturer's authorized representative shall perform complete functional test of each system and submit written report to Contractor attesting to proper operation of completed system prior to final inspection.

B. Contractor shall test each device in system before system is considered substantially complete.

C. Completed fire alarm system shall be fully tested by Contractor in presence of the Owner's representative and local Fire Marshal.

D. Perform the following field tests and inspections and prepare test reports:

1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72 and as required by the City of Chicago Bureau of Fire Prevention.
2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72 and as required City of Chicago Bureau of Fire Prevention. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level II.
   a. Include the existing system in tests and inspections.

3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.
4. Testing: Follow procedure and record results complying with requirements in NFPA 72 and City of Chicago Bureau of Fire Prevention.
   a. Detectors that are outside their marked sensitivity range shall be replaced.

E. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing
   a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
   b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA72.

F. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

G. Fire-alarm system will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

I. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

J. Annual Test and Inspection: During the warranty period, each year test fire-alarm system complying with visual and testing inspection requirements in NFPA72. Use forms developed for initial tests and inspections.

K. Detector Sensitivity Testing: During the warranty period, each year the contractor is to perform detector sensitivity testing and provide report to the Owner. Unless, the system is UL Listed to perform automatic sensitivity testing without any manual intervention and should detector fall outside of sensitivity window, the system will automatically indicated a devices trouble. A copy of UL letter is to be provided as proof of system operation

L. Include in the test procedure demonstration that interfaces with other building systems (security, elevators, building managements system, etc.) operate as required.

M. The final acceptance test shall be witnessed by the inspectors from both: City of Chicago Bureau of Electrical Inspection and City of Chicago Bureau of Fire Prevention. The acceptance test shall be performed using the initial testing procedure from the “Bureau of

Fire Prevention Guidelines for the Testing and maintenance of Fire Alarm System". The installer of the system and technician from the fire alarm system manufacturer must be present for the official acceptance test.

N. Upon completion of successful test, Contractor shall:

1. Certify system to Owner in writing
2. Complete NFPA 72 required record of completion form.
3. Provide as-built drawings and O&M manuals.

O. Reference Section 16700

3.4 ADJUSTING

A. Occupancy Adjustments: Within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

B. Follow-Up Tests and Inspections: After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72 and as required by the City of Chicago Bureau of Fire Prevention. Perform tests and inspections listed for three monthly, and one quarterly, periods.

C. Semiannual Test and Inspection: Six months after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72 and as required by the City of Chicago Bureau of Fire Prevention. Perform tests and inspections listed for monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

D. Annual Test and Inspection: One year after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, semiannual, and annual periods. Use forms developed for initial tests and inspections.

3.5 TRAINING

A. Contractor shall provide minimum of 8 hrs system operation training for Owner, Architect/Engineer, and Fire Department personnel.

B. Training session shall be at time to be stipulated by Owner.

C. Training shall be completed prior to final inspection.

3.6 MAINTENANCE CONTRACT

A. Equipment manufacturer shall make available to Owner, maintenance contract proposal to provide minimum of 2 inspections and tests per year in compliance with NFPA-72 Codes and City of Chicago Bureau of Fire Prevention.

B.- P**rovide full maintenance service for 2 years from date of substantial completion. Warranty shall extend 2 years from date of substantial completion. Extended maintenance to include 24/7 emergency call-back service with 2 hour or less response time.**

END OF SECTION 16721

SECTION 17115a

SUMMARY OF WORK

WORK	FURNISH	INSTALL	LOW VOLT WIRING/ CONDUIT	LINE POWER WIRING/ CONDUIT
General	**Furnish**	**Install**	**Low Volt**	**Line Power**
EMS low voltage and communication wiring	SI	SI	SI	N/A
EMS conduits and raceways	SI	SI	SI	N/A
120/1/60 power from Electrical Panel to EMS panels	SI	SI	N/A	SI
EMS controllers, enclosures, panels	SI	SI	SI	SI
Piping wells, hydronic diff pressure switches	SI	MC	SI	N/A
Electrical Systems	**Furnish**	**Install**	**Low Volt**	**Line Power**
Wiring between main switchboard 1-H and EMS	SI	SI	SI	N/A
Wiring between Emerg. Gen. and EMS	SI	SI	SI	N/A
Wiring between ATSs and EMS	SI	SI	SI	N/A
Wiring between lighting control panel and EMS	SI	SI	SI	N/A
Hot Water / DHW Systems	**Furnish**	**Install**	**Low Volt**	**Line Power**
HW Pump VFDs	MC	EC	SI	EC
Control valves	SI	MC	SI	SI
Wiring between kill switch and boilers	SI	SI	SI	SI
DHW control valves (on HW side)	MC-Plbg	MC-Plbg	SI	N/A
DHW pump RP-1 control	MC-Plbg	MC-Plbg	SI	MC-Plbg
Boiler misc. controls	MC	SI	SI	EC

Chilled Water System	**Furnish**	**Install**	**Low Volt**	**Line Power**
Control valves	TCC	MC	SI	SI
Wiring between chillers and EMS	TCC	SI	SI	SI
Proprietary-to-LON interface – chiller	SI	factory	N/A	N/A
AHU	**Furnish**	**Install**	**Low Volt**	**Line Power**
OA, RA, EA, isolation and cross-over dampers	SI	MC	N/A	N/A
Damper actuators	SI	SI	SI	SI
Control valves	SI	MC	SI	SI
Duct smoke detectors	SI	MC	SI	SI
Supply and Return Fan VFDs	MC	EC	SI	EC
Air flow measuring stations	SI	MC	SI	N/A
Humidifiers	MC	MC	SI	EC
Terminal Unit	**Furnish**	**Install**	**Low Volt**	**Line Power**
FPMBs and VAV boxes	MC	MC	SI	EC
Terminal Unit controls (including primary air damper actuator, CO_2 and humidity sensors, override button)	SI	SI	SI	SI
Terminal Unit RHC valves	SI	MC	SI	N/A
FTR valves	SI	MC	SI	N/A
Exhaust Fans	**Furnish**	**Install**	**Low Volt**	**Line Power**
EF controls	SI	SI	SI	SI
EF VFDs (EF-1 and 6 only)	MC	EC	SI	EC
Relay/contactors (as required for 1-ph and 3-ph)	SI	SI	SI	EC
Relay/contactors for light switch status	SI	SI	SI	EC
EF barometric backdraft dampers	MC	MC	N/A	N/A
EF motorized dampers	SI	MC	N/A	N/A
EF motorized damper actuators	SI	SI	SI	N/A
UH and CUH	**Furnish**	**Install**	**Low Volt**	**Line Power**
controls	MC	MC	SI	SI
CUH automatic valves	MC	MC	SI	N/A
CUH auquastats	MC	MC	SI	N/A
Computer Room (AC2-1, P-10, CH-3)	**Furnish**	**Install**	**Low Volt**	**Line Power**
Interlock wiring	N/A	N/A	SI	EC
Monitor points between HVAC components and EMS	SI	SI	SI	SI

Fan Coil Units	**Furnish**	**Install**	**Low Volt**	**Line Power**
FCU controls	SI	SI	SI	SI
FCU automatic valves	MC	MC	SI	N/A
Miscellaneous	**Furnish**	**Install**	**Low Volt**	**Line Power**
Wiring between Fire Pump and EMS	SI	SI	SI	N/A
Wiring between main water meter and EMS	SI	SI	SI	N/A
Wiring between irrigation meters and EMS	Note 1	Note 1	Note 1	Note 1
Abbreviations	SI	Systems Integration Contractor		
	MC	Mechanical Contractor (HVAC)		
	EC	Electrical Contractor		
	N/A	Not Applicable		
	MC-Plbg	Mechanical Contractor (Plumbing)		

Note 1: Conduit between main irrigation control panel in the building and the (5) remote irrigation panels is provided by Division 16. Control wiring for the irrigation system including pulling of wire through conduit and termination will be provided by the contactor providing the irrigation system. This same contractor will also pull but not terminate control wiring for EMS monitoring of remote meters between irrigation meters and the irrigation main panel. This contractor will coordinate with the contractor providing the EMS. The EMS contractor will furnish the wire used for its system.

END OF SECTION

SECTION 17750

RADIO EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents

C. Book 2: Standard Terms and Conditions for Construction Contracts

D. Book 2A: Standard Terms and Conditions Procedures Manual

1.2 SUMMARY

A. This Section specifies a radio equipment & antenna system to ensure that nearby surrounding police zones where it can be reasonably anticipated the site will provide coverage into the police zone geographic area and where a police officer from an adjacent zone can reasonably expect nearby coverage out of their zone boundary. System integration is to be coordinated with the Office of Emergency Management and Communications ("OEMC"), the Owner and Owner's Designees.

B. This Section specifies installation of radio equipment. Radio antennas to be installed under Section 13400.

1.3 SUBMITTALS

A. Comply with requirements of Section 17000 for Submittals.

B. Product Data: Provide manufacturer's catalog information and technical data sheet(s) showing physical and electrical transmission characteristics, dimensions, features, functionality, and configurations.

C. Shop drawings:
   1. As-built drawings, diagrams and calculations, reflecting as-installed conditions.

1.4 QUALITY ASSURANCE

A. Comply with requirements of Section 17000 for Quality Assurance.

B. Comply with applicable FCC specifications. OEMC will be responsible for obtaining required licenses utilizing information supplied by manufacturer.

C. Pre-qualified Radio Equipment Subcontractor:
   1. Motorola

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 17000 for Delivery, Storage, and Handling.

1.6 COORDINATION

A. Comply with requirements of Section 17000 for Coordination.

1.7 WARRANTY

A. The warranty shall cover all material, services, products and operation of the radio equipment and system for a minimum period of two (2) years from date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Radio Equipment:

1. Motorola

2.2 SYSTEM REQUIREMENTS

A. The Contractor shall provide a turnkey installation. This includes, but is not limited to, system design, integration, installation and adjustment of the Radio Equipment to provide a complete and fully functioning system.

1. System shall provide 100% signal coverage, at minimum dB signal strength. Each receiver's receive sensitivity will be measured and recorded. Each transmitters power output supplied to the main feed line will be measured and recorded.

2. Head-end system equipment shall be rack-mounted.

3. Provide antenna(s) suitable to application, and in accordance with system performance specifications.

4. For non-Chicago Fire Digital (CFD) channels contractor to provide turnkey installation of RF interfaces to the devices (Antenna to device), audio connections for the channels will be done by the OEMC.

2.3 Material Lists:

	Description	Frequency	PL	Mode
1	VHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Main Fire)	153.950	5A (156.7)	Wide Band Analog
2	VHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Englewood Fire)	154.0100	5A (156.7)	Wide Band Analog
3	VHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Admin)	154.2200	5A (156.7)	Wide Band Analog
4	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (EMS Main)	465.6000	5A (156.7)	Wide Band Analog
5	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (EMS Englewood)	465.6250	5A (156.7)	Wide Band Analog
6	CFD Simulcast EMS North (Note 1)	480.5125	405	P25
7	CFD Simulcast EMS South (Note 1)	481.4624	211	P25
8	CFD Simulcast Fire City-Wide (Note 1)	479.6875	ADB	P25
9	CFD Simulcast Fire Main (Note 1)	480.7875	EC3	P25
10	CFD Simulcast Fire Englewood (Note 1)	481.2125	84D	P25
11	CFD Simulcast OEM (Note 1)	480.9875	693	P25
12	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (CTA Tunnel)	465.0625	203.5 Hz	Narrow Band Analog
13	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Med 9)	467.9500	203.5 Hz	Narrow Band Analog
14	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Med 10)	467.9750	5A (156.7)	Wide Band Analog
15	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 3)	465.2250	2Z 110.9	Wide Band Analog

16	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 4)	465.1500	2A (114.8)	Wide Band Analog
17	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 5)	465.5000	6Z (179.9)	Wide Band Analog
18	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 6)	465.4000	5A (156.7)	Wide Band Analog
19	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 7)	465.0750	4B (146.2)	Wide Band Analog
20	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 10)	465.1000	5Z (151.4)	Wide Band Analog
21	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 12)	465.425	ZA 94.8	Wide Band Analog
22	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (Zone 13)	465.450	1A (103.5)	Wide Band Analog
23	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 1)	465.1250	6A (173.8)	Wide Band Analog
24	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 2)	465.1750	3Z (123.0)	Wide Band Analog
25	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 3)	465.2750	4A (141.3)	Wide Band Analog
26	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 4)	465.3250	7A (192.8)	Wide Band Analog
27	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 5)	465.3500	ZB (97.4)	Wide Band Analog

28	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 6)	465.2500	5B (162.2)	Wide Band Analog
29	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (City-Wide 7)	465.3000	3B (131.8)	Wide Band Analog
30	Quantar Base Station Repeater #725-185-2783 100 watt repeater, triple circulator, duplexer add Spectra Tac operation X269 #725-185-2760 add Enhanced Wildcard X157 #725-185-2940 add Antenna Relay X--- # Capable of wide band analog emissions, narrow band analog emissions, P25 digital emissions (CAI) (CFD District 4 Emergency)	TX 477.7625 RX 480.7625	5A (156.7)	Narrow Band Analog
31	UHF Astro Spectra Receiver. Capable of receiving emissions of wide band analog FM, narrow band analog FM, APCO P25 digital emissions (CAI), Spectra Tac conventional encoder. (CFD District 4 Emergency)	477.7625	5A (156.7)	Narrow Band Analog
32	Antenna Andrews, DB638, 8 db gain, 14 foot or similar	450 MHz to 482 MHz	150 ft Platform	Qty 1
33	Antenna Andrews, DB224, 6 to 9 db gain or similar	155 MHz to 160 MHz	150 ft Platform	Qty 1
34	Antenna Andrews, DB 420, 8 bay, 9.2/10.4 db gain or similar	450 MHz to 470 MHz	150 ft Platform	Qty 1
35	Antenna Andrews, DB812KE-XT, 12 db or similar	806 MHz to 869 MHz	150 ft Platform	Qty 1
36	Antenna Andrews, DB420, 8 bay, 9.2/10.4 db gain or similar	450 MHz to 470 MHz	130 ft Platform	Qty 2
37	Antenna Andrews, DB224, 6 to 9 db gain or similar	155 MHz to 160 MHz	130 ft Platform	Qty 1
38	Antenna Andrews DB586XT, 6 db or similar	806 MHz to 869 MHz	130 ft Platform	Qty 3
39	GPS receiver with 24 outputs configurable for 5 MHz, 1 PPS, or Composite with redundant antennas and power supplies.	Satellite	On Building	Qty 1
40	Antenna Cable, Andrews 7/8” LDF5-50A	Note 2		
41	Antenna Cable, Andrews 1/2” LDF4-50A	Note 2		

42	Polyphasors for 7/8" hardline to ½" hardline.	Note 2		Qty 10
43	Flexible RF Jumper Cable from ½" hardline to RF equipment. Acceptable Models would be Tessco Part Number 418470 (Andrews L4A-PNMNM –4-USA)	Note 4	4 ft each	Qty 32
44	MOSCAD for 6 Chicago Fire Digital channels consisting of multiple CPU and Mux ports to enable monitoring of the channels, control of the switch, monitoring of the Channel banks, monitoring of the GPS receiver, and monitoring of the CFD multi-coupler. Necessary licensing to be included.	Note 1		Qty 1
45	Channel Bank for 6 Chicago Fire Digital channels for conductivity bank to OEMC and BCF	Note 1		Qty 1
46	Switch for control of CFD system Comparator location selection	Note 1		Qty 1
47	Channel Bank Cards for OEMC and BCF to allow for conductivity to District 12 (Consisting of necessary WAN cards and SRU cards)			
48	48 Position Bantam Jackfield (DSJC248M)			Qty 2
49	25 Pair F/F 5 Ft (DQ253CC5GY)			Qty 12
50	25 Pair M/M 10 Ft (DQ253PP10GY)			Qty 12
51	10RJ21X FML to 10 QCBIX1A (DQA0321776)			Qty 4
52	EMR Pre-selector multi-coupler for UHF, 465.0000 to 465.6250 MHz, 32 Ports			Qty 1
53	EMR Pre-selector for VHF, 154 to 156 MHz +/-, 4 Port.			Qty 1
54	CFD Pre-selector multi-coupler for UHF, 479.6875 to 481.4625 MHz, 8 Port. (P25 digital simulcast receivers).			Qty 1
55	4" 18 lb Cable tie Natural Bag of 1000			Qty 4
56	7.5" 50 lb Cable tie Natural Bag of 1000			Qty 4
57	14.75" 120 lb Cable tie Natural Bag of 1000			Qty 4

Note 1: T-Band digital simulcast receivers project to include

A. All receivers mounted/installed at 1412 S. Blue Island
B. All antennas mounted on monopole as specified
C. All antennas to be fed with 7/8" Andrews LDF5-50A hardline
D. Monopole to have a 5 ohm or less ground independent of the building halo or grounding system
E. All antennas to be provided with a polyphasor lightning arrestor at the entrance panel
F. All radio equipment shall be traceable to a building ground
G. City to supply T1 line to the OEMC
H. City to supply T1 line to the BCF, 2111 W. Lexington
I. Contractor to supply and install GPS receiver and hardware 1412 S. Blue Island
J. Contractor to modify existing digital simulcast system at the OEMC and BCF to accept new receive only site
K. Contractor to program MOSCAD monitoring device at the OEMC and BCF
L. Contractor to provide all cabling within the racks to allow for system to operate.
M. Contractor to provide necessary switching gear to allow for comparator location selection.

Note 2: The exact length of Andrews 7/8" hardline LDF5-50A and Andrews LDF4-50A can only be estimated. The exact length of hardline required can be estimated at ten (10) feedlines at 200 feet each. Each feedline will require a connector at the top of the tower and a connector inside room at the entrance panel. A polyphasor for each antenna and feedline is required at the entrance panel along with a master ground bus bar. Polyphasors may be frequency and RF power level dependent.

Length of Andrews ½" LDF4-50A may be estimated at ten (10) cables fifty (50) foot each. Cable to reach from entrance panel to RF equipment. Connects to Polyphasor terminating 7/8" hardline. Termination near RF equipment should be provisioned with N male connector.

Contractor to install RF cable grounding at intervals as specified by R56 standards.

Polyphasors required for:

A. Item #32, Receive only antenna
B. Item #33, Receive only antenna
C. Item #34, Receive only antenna
D. Item #35, Receive only antenna
E. Item #36, Qty of two (2) 100 watt transceiver 460 MHz
F. Item #37, 100 watt transceiver 155 MHz
G. Item #38, Quantity of three (3) 850 MHz transceivers 50 watt.

Note 3: Master ground bus bar to provide low DC resistance and low impedance to building master ground. One master ground bus bar required at RF entrance panel and at least one required near RF equipment. Must be a traceable ground.

Note 4: Jumper cable from ½" LDF to actual RF equipment. Must be flexible and provide 100% braid covering.

Note 5: Must have Cable Tray installed. Cable tray must be minimum of two (2) feet wide and maximum of three (3) feet wide. Must be six (6) inches deep. Cable tray to be provisioned with factory 90 degree bends where applicable. It is anticipated the cable tray will be in a "U" shape with the long arms extending the length of the concrete pad designated as the mounting locations for the radio equipment cabinets and relay rack frames. The bottom of the "U" is generally where the waveguide entrance panel is located. Cable tray must have ten (10) foot clearance from the bottom of the cable tray to the floor.

2.4 Power consumption of equipment (See updated Excel Sheet):

Item	Description	AC Circuit	Power in Amps	Power in watts
1	Astro Spectra Receiver	1	0.5 A	50 W
2	Astro Spectra Receiver	1	0.5 A	50 W
3	Astro Spectra Receiver	1	0.5 A	50 W
4	Astro Spectra Receiver	1	0.5 A	50 W
5	Astro Spectra Receiver	1	0.5 A	50 W
6	Quantar Receiver	1	0.5 A	50 W
7	Quantar Receiver	1	0.5 A	50 W

8	Quantar Receiver	1	0.5 A	50 W
9	Quantar Receiver	1	0.5 A	50 W
10	Quantar Receiver	1	0.5 A	50 W
11	Quantar Receiver	1	0.5 A	50 W
12	Astro Spectra Receiver	1	0.5 A	50 W
13	Astro Spectra Receiver	1	0.5 A	50 W
14	Astro Spectra Receiver	1	0.5 A	50 W
15	Astro Spectra Receiver	1	0.5 A	50 W
16	Astro Spectra Receiver	1	0.5 A	50 W
17	Astro Spectra Receiver	1	0.5 A	50 W
18	Astro Spectra Receiver	1	0.5 A	50 W
19	Astro Spectra Receiver	1	0.5 A	50 W
20	Astro Spectra Receiver	1	0.5 A	50 W
21	Astro Spectra Receiver	1	0.5 A	50 W
22	Astro Spectra Receiver	1	0.5 A	50 W
23	Astro Spectra Receiver	1	0.5 A	50 W
24	Astro Spectra Receiver	1	0.5 A	50 W
25	Astro Spectra Receiver	1	0.5 A	50 W
26	Astro Spectra Receiver	1	0.5 A	50 W
27	Astro Spectra Receiver	1	0.5 A	50 W
28	Astro Spectra Receiver	1	0.5 A	50 W
29	Astro Spectra Receiver	1	0.5 A	50 W
30	Quantar Base Station	1	8.5 A	1000 W
31	Astro Spectra Receiver	1	0.5	50 W
39	GPS Receiver	2		320 W
44	MOSCAD Power Supply	1		360 W
45	Channel Bank	2		270 W
46	Switch	2		288 W
52	EMR Multicoupler	1		100 W
53	EMR Multicoupler	1		100 W
54	CFD Multicoupler	1		100 W
X	Power Strips	2		500 W
X	Adtran T1 Chassis	2	3.75	450 W
X	On-Site Test Equipment	2	15	X
X	Miscellaneous 1	1	15	X
X	Miscellaneous 2	1	15	X

Minimum Power consumption = 8,000 watts.

2.5 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. J-hooks and D-rings.
2. Cable ties, straps and other devices: For securing cables at head-end equipment.

C. Comply with requirements of Division 16 for Supporting Devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate cable routing and placement of antennas with work of other trades. The antennas shall be installed under section 13400.

B. Do not route cables in same conduits or sleeves with voice/data UTP cabling. Utilize dedicated sleeves through walls for cable routing. Coordinate with Division 16 on location of sleeves.

3.2 IDENTIFICATION

A. Equipment: Each piece of equipment shall be permanently identified in such a manner that the equipment can be easily traceable to the source of the manufacture. Tags shall indicate, as a minimum, manufacturer's name, model and serial number.

3.3 FIELD TESTING AND ADJUSTMENT

A. The Contractor shall be responsible for the proper adjustment and operation of each individual system as described within this document and shall provide all test equipment for the system test and acceptance phases.

3.4 FIRESTOPPING

A. Comply with requirements of Section 17000 for Firestopping.

3.5 GROUNDING AND BONDING

A. Comply with requirements of Section 17000 for Grounding and Bonding.

END OF SECTION 17750

SECTION 17830

INTEGRATED AUTOMATION MATERIALS, I/O DEVICES, AND SENSORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings.

B. Book 1: Project Information, Instructions to Bidders, and Execution Documents.

C. Book 2: Standard Terms and Conditions for Construction Contracts.

D. Book 2a: Standard Terms and Conditions Procedures Manual.

1.2 SUMMARY

A. System Integrator shall supply and install the components listed in this section and those identified on the project drawings in adequate quantities and in calibrated locations, as required, to meet the sequence of operation and design / performance intent of the MEP and other related systems as they pertain to the IAS and functional operation.

B. Provide products compliant with the following sections for all devices specified and as indicated on the project drawings. If substitutions are necessary or warranted, follow the substitution submittal procedure defined in the project specifications. This section shall address the product requirements for the following components.

C. Wiring.

D. Control Valves and Actuators.

E. Control Dampers and Actuators.

F. Control Panels.

G. Sensors.

H. Pneumatic Control Components (Gauges, Switches, Relays, etc.).

I. Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).

J. Transducers.

K. Current Switches.

L. Thermowells.

M. Thermistors.

N. Power Meters.

O. Snow and Ice Detectors

P. Nameplates.

Q. Testing Equipment.

R. Refer to Section 17800 for general requirements.

S. Refer to Division 15 for installation of instrument wells, valve bodies, and dampers in mechanical systems; not Work of this Section.

T. Provide the following electrical work as work of this Section, complying with requirements of Division 16 Sections.

1. Control wiring between field-installed controls, indicating devices, and unit control panels.
2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
3. Wiring associated with annunciation and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

1.4 WORK BY OTHERS

A. Control Valves furnished under this Section shall be installed under the applicable piping Section under the direction of the System Integrator who will be fully responsible for the control wiring and for the proper operation of the valve.

B. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the System Integrator who will be fully responsible for the control wiring and the proper operation of the damper.

C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc that will have wet surfaces furnished under this Section, shall be installed under the applicable piping

Section under the direction of the System Integrator who will be fully responsible for the control wiring and the proper installation and application of these devices.

D. Controlled Equipment Power Wiring shall be furnished and installed under Division 16. Where control involves 120 volt (V) control devices controlling 120V equipment, Division 16 System Integrator shall extend power wiring to the equipment. System Integrator shall extend it from the equipment to the control device.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. All control devices shall be electronic using DDC control unless specified on the drawings.

C. Provide electronic, pneumatic, and electric control products in sizes and capacities indicated, consisting of valves, dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

2.2 MATERIALS AND EQUIPMENT

A. Instrument Pipe and Tube:

1. Hydronics and Instruments:

a. Connection to Main Piping: Provide ½ inch minimum size threadolet, ½ inch x 2 inch brass nipple, and ½ inch ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.

b. Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼ inch FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.

c. Line Mounted Instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.

d. Instrument Tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition

solder. Tubing outside diameter size shall be not less than the larger of ¼ inch or the instrument connection size.

e. Rigid Piping for Line Mounted Instruments: Schedule 40 threaded brass, with threaded brass fittings.

2. Low Pressure Air Instrument Sensing Lines

a. Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.

b. Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

B. Communication Wiring: All wiring shall be in accordance with the latest edition of the National Electrical Code and Division 16. Communication wiring shall be provided in a customized color jacketing material. Material color shall be as submitted and approved by Owner. In addition all wiring jackets shall be factory labeled as "IAS or BAS or BMS or Communications" in three (3) foot or fewer intervals along the length of the jacket material. Each end of the wire, originating and terminating end shall have a unique label identifying the purpose of the wire. An example of the required submittal and the application is provided below:

Purpose	Function	Color	Unique Label
Primary Communications LON	Field Device Communication	Orange	Refer to 17810 Article 3.06
Spare Primary Communication LON	Field Device Communication	Green	Refer to 17810 Article 3.06
Secondary Communications LON	Equipment Integration	Purple	Refer to 17810 Article 3.06
Spare Secondary Communication LON	Equipment Integration	Gray	Refer to 17810 Article 3.06
FACLAN	Enterprise Network	Dark Blue	Refer to 17810 Article 3.06
Spare FACLAN	Enterprise Network	Light Blue	Refer to 17810 Article 3.06
Analog Points	I/O Wiring	White	Refer to 17810 Article 3.06
Digital Points	I/O Wiring	White / Black Stripe	Refer to 17810 Article 3.06
Emergency Power	Control power	Yellow / Black Stripe	Refer to 17810 Article 3.06
24VAC	control power	Yellow	Refer to 17810 Article 3.06
Purpose	Function	Color	Unique Label
Building Level	Communication	Orange	IAS Building Level Communication / NC – 10 to Network Switch-04
Floor level	Communication	Blue	IAS Floor Level Communication / DCP-12 to DCP-13

Purpose	Function	Color	Unique Label
Inputs/Outputs	Panel to device	White	IAS Input Output Device Cable / MAT to DCP-08
24VAC	control power	White/Black tracer	IAS 24 VAC Control Power / CKT 15B to DCP-09

1. System Integrator shall supply all communication wiring between Network Controllers, Routers, Gateways, PCU's, ASC's, RIO's and local and remote peripherals (e.g., operator workstations, printers, and modems).
2. Local Supervisory FACLAN: For any portions of this network required under this Section of the Specification, System Integrator shall use multimode fiber (62.5 micron) or Category 5E cable per TIA/EIA 68 (10BaseT). Network shall be run with no splices and separate from any wiring over thirty (30) volts.
3. Primary and Secondary Controller LONs: Communication wiring shall be individually 100 percent shielded pairs per manufacturer's recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated and wiring shall be grounded as recommended by building controller manufacturer.

C. Signal Wiring: System Integrator shall run all signal wiring in accordance with the latest edition of the National Electrical Code and Division 16.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100 percent shielded pair, minimum 18-gage wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

D. Low Voltage Analog Output Wiring: System Integrator shall run all low voltage control wiring in accordance with the latest edition of the National Electrical Code and Division 16.

1. Low voltage control wiring shall be minimum 18-gage, twisted pair, 100 percent shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices and separated from any wiring above thirty (30) volts.

E. Control Panels: Refer to 2.07 in Section 17850.

2.3 STANDARD SERVICE CONTROL VALVES

A. Control valve sizing and selection is the initial responsibility of the Engineer and not left to the System Integrator. Engineer shall provide a valve schedule that lists the requirements of the valves for Cv, close off, temperature etc. This should be a result of analyzing the valves performance across the range of control.

B. General:

1. Provide factory fabricated control valves of type, body material and pressure class indicated.
2. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system.
3. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve.
4. Control valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application.
5. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

C. Plug-Type Globe Pattern for Water Service:

1. Valve Sizing: Where not specifically indicated in the Contract Documents, modulating valves shall be sized for maximum full flow pressure drop between 50 percent and 100 percent of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping. Refer to division 15 specifications for additional valve specification, selection, and sizing requirements.
2. Single Seated (Two-way) Valves: Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections to campus systems unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on 'top-and-bottom' guided plugs.
3. Double Seated (Three-way) Valves: Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on 'top-and-bottom' guided plugs.
4. Temperature Rating: 25 degrees F minimum, 250 degrees F maximum.
5. Body: Bronze, screwed, 250 psi maximum working pressure for ½ inch to 2 inch; Cast iron, flanged, 125 psi maximum working pressure for 2-1/2 inches and larger.
6. Valve Trim: Bronze; Stem: Polished stainless steel.
7. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
8. Plug: Brass, bronze or stainless steel, Seat: Brass.
9. Disc: Replaceable composition or stainless steel filled PTFE.
10. Ambient Operating Temperature Limits: -10 to 150 degrees F (-12.2 to 66 degrees C).
11. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:

    a. Johnson Controls.
    b. Invensys.
    c. Warren.
    d. Delta.

D. Pressure Independent Valves for Water Service:

1. Valves 2" and less: For valves 2" and less, use Belimo pressure independent valves or approved equal in accordance with specification section 01631,

"Substitutions", of this specification. Valves shall be rated for fluid type and 150% of the system operating pressure and temperature.

2. Valves 2-1/2" and greater: For valves 2-1/2" to 8" valves use Flow Control Industries pressure independent valve or approved equal in accordance with specification section 01631, "Substitutions", of this specification. Valves shall be rated for fluid type and 150% of the system operating pressure and temperature.
   a. Valves shall be cast iron or cast carbon-steel flanged construction with stainless steel valve stems and brass or bronze valve plugs.
   b. Operating temperature range shall be 20 to 250ºF, and they shall be rated for ANSI Class 125 working pressure.

E. Butterfly Type: To be used for two-position control only, unless prior approval is obtained from Owner.

1. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
2. Seat: EPDM, except in loop bypass applications where seat shall be metal to metal.
3. Disc: Bronze or stainless steel, pinned or mechanically locked to shaft.
4. Bearings: Bronze or stainless steel.
5. Shaft: 416 stainless steel.
6. Cold Service Pressure: 175 psi.
7. Close Off: Bubble-tight shutoff to 150 psi.
8. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more that 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the Owner.
9. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:

   a. Keystone.
   b. Jamesbury WS815.
   c. Bray Series 31.
   d. Dezurik BGS.

F. Ball Type:

1. Body: Brass or bronze; one-, two-, or three-piece design; threaded ends.
2. Seat: Reinforced teflon.
3. Ball: Stainless steel.
4. Port: Standard or 'V' style.
5. Stem: Stainless steel, blow-out proof design, extended to match thickness of insulation.
6. Cold Service Pressure: 600 psi WOG.
7. Steam working Pressure: 150 psi.
8. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:

   a. Conbraco.
   b. Worcester.
   c. Nibco.

d. Jamesbury.
e. PBM.
f. Delta.

G. Segmented or Characterized Ball Type:

1. Body: Carbon steel (ASTM 216), one-piece design with wafer style ends.
2. Seat: Reinforced teflon (PTFE).
3. Ball: Stainless steel ASTM A351.
4. Port: Segmented design with equal-percentage characteristic.
5. Stem: Stainless steel.
6. Cold Service Pressure: 200 psi WOG.
7. Cavitation Trim: Provide cavitation trim where indicated and/or required, designed to eliminate cavitation and noise while maintaining an equal percentage characteristic. Trim shall be a series of plates with orifices to break the pressure drop into multi-stages.
8. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:

a. Jamesbury R-Series.
b. Fisher.
c. Belimo.

2.4 CRITICAL SERVICE CONTROL VALVES

A. Control valve sizing and selection is the initial responsibility of the Engineer and not left to the System Integrator. Engineer shall provide a valve schedule that lists the requirements of the valves for Cv, close off, temperature etc. This should be a result of analyzing the valves performance across the range of control. Refer to the 'Control Valve Specification Sheet' located at the end of this Section.

B. General:

1. Provide factory fabricated control valves of type, body material and pressure class indicated on the 'Control Valve Specification Sheet' located at the end of this Section. System Integrator shall utilize the sheet to submit the control valves for the Project.
2. Valves shall be as manufactured by Fisher Controls International, Valtek Control Products, DeZurik/Copes-Vulcan, Keystone, Leslie Controls Inc., or equal.
3. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system.
4. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve.
5. Control valves shall be equipped with heavy-duty actuators and pilot positioners with proper close-off rating and capability for each individual application.
6. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

2.5 CONTROL DAMPERS

A. Size all dampers and actuators for the appropriate application and submit this information on a damper schedule as noted in the Submittals section of part 1 of this specification.

B. All 2-position control dampers shall be duct size.

C. All modulating control dampers shall be sized by the contractor installing the EMS to allow for proper control and pressure drops.

D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1,500 FPM, and not greater than 5 sqft:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gage minimum thickness.
4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than one percent based on approach velocity of 1500 fpm (7.62 m/s) and 1 inches wg. (249Pa).
10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa).
11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for installation.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

    a. Arrow
    b. TAMCO
    c. Cesco Products

E. For applications with duct or opening areas greater than 5 sqft that DO NOT provide isolation to outdoors and function in a general isolation and modulating control service in rectangular ducts at velocities exceeding 1,500 FPM:.

1. Leakage shall be no more than 1% at 1500 FPM approach velocity at 4" static closing torque. Submit leakage and flow characteristics for all control dampers. Standard air leakage data to be certified under the AMCA certified ratings program.
2. Frames shall be extruded aluminum.

3. Damper blades to be extruded aluminum profiles. Blade ends to be capped in order to seal hollow interior and minimize air leakage possibilities.
4. Blade gaskets and frame seals shall be extruded silicone. Gaskets to be secured in an integral slot within the aluminum extrusions.
5. No blade shall be greater than 8" width or 48" length, and dampers shall be available for either opposed or parallel blade action.
6. Dampers to be designed for temperatures ranging between 0°F and 150°F, and shall have a pressure drop of a full open 48" X 48" damper shall not exceed .02"w.g. at 1,000 fpm.
7. Dampers shall be available in two mounting types: i.e. "Installed in Duct" or "Flanged to Duct", and installation of dampers shall be in accordance with manufacturer's installation guidelines.
8. Acceptable Damper Manufacturers:

    a. Arrow United Industries, Model ADF-20
    b. TAMCO, Series 1500
    c. Cesco Products, Model IAA/B-6

F. For all outside air intake or exhaust control dampers that DO provide isolation to outdoors or otherwise need to provide thermal isolation.

1. Performance: Test in accordance with AMCA 500.
2. Frames: Extruded aluminum hat channel.
3. Damper Blades: Extruded aluminum profiles. Blade ends to be capped in order to seal hollow interior and minimize air leakage possibilities. Blades shall be de-bridged for thermal isolation.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Non-metallic seal.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than 0.1 percent based on approach velocity of 4,000 ft./min. and 1 inches w.g.
10. Maximum Pressure Differential: 6 inches w.g.
11. Temperature Limits: -40 to 200°F .
12. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts. For multiple dampers driven by a jackshaft the shaft will rigid in torsion and driven by at least two actuators located at either end of the shaft.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

    a. Arrow United Industries, Model ADFTI-20
    b. TAMCO, Series 9000
    c. Cesco Products, Model ITAB/ITBB

G. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4 inches w.c. (994 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Rolled 12 gage steel strip for sizes 6 inch and smaller, rolled 14 gage steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 12 gage minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gage minimum thickness for larger dampers.
4. Blade Seals: Full circumference neoprene.
5. Shaft: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.
6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 4 inches wg. (994 Pa).
9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).

2.6 CONTROL DAMPERS

A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. Provide parallel or opposed blade dampers as recommended by manufacturer's sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.

B. All 2-position control dampers shall be duct size.

C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm, and not greater than 5 sqft:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gage minimum thickness.
4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than one percent based on approach velocity of 1500 fpm (7.62 m/s) and 1 inches wg. (249Pa).
10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa).

11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for installation.

D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6 inches w.c. (1493 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gage minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than 0.1 percent based on approach velocity of 4000 fpm. (20.3 m/s) and 1 inches wg. (249Pa).
10. Maximum Pressure Differential: 6 inches wg. (622 Pa).
11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for the installation.

E. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12 inches w.c.:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 12-gage minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws.
4. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
5. Linkage: 10-gage minimum thickness galvanized steel clevis type crank arms, 3/16 inch x ¾ inch (4.76 mm x 19 mm) minimum thickness tie rods.
6. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 12 inches wg. (2984 Pa).
9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).

10. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for the installation.

F. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4 inches w.c. (994 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Rolled 12 gage steel strip for sizes 6 inch and smaller, rolled 14 gage steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 12 gage minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gage minimum thickness for larger dampers.
4. Blade Seals: Full circumference neoprene.
5. Shaft: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.
6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 4 inches wg. (994 Pa).
9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).

G. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6 inches w.c. (1492 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: Rolled 10-gage steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 10-gage minimum thickness for dampers not greater than 48 inches in size, ¼ inch (6.35 mm) minimum thickness for larger dampers.
4. Blade stops: ½ inch x ¼ inch (12.7 mm x 6.35 mm) full circumference steel bar.
5. Blade Seals: Full circumference neoprene.
6. Shaft: Zinc or cadmium plated steel, angle reinforcing as necessary.
7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. Leakage: Less than 0.4 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
9. Maximum Pressure Differential: 6 inches wg. (1492 Pa).
10. Temperature Limits: -40 to 250 degrees F (-40 to 121 degrees C).

2.7 ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied. Manual override shall allow the user to disengage the valve / damper from the actuators motor for manual operation. Large valve actuators shall provide fly wheel for manual operation.

B. Actuators General Requirements:

1. Ambient Operating Temperature Limits: -10 to 150 degrees F (-12.2 to 66 degrees C).
2. Two Position Electric Actuators: Line voltage (120 volt, 24 volt) with spring return. Provide end switches as required.
3. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, as required. Actuators shall travel full stroke in less than 90 seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated. Modulating actuators for valves shall have minimum rangeability of 40 to 1.
4. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
5. Manufacturer shall provide a 2 year unconditional warranty from date of substantial completion.
6. Sound levels for VAV actuators shall not exceed 45 dB.
7. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch actuators are not acceptable.
8. Subject to compliance with requirements, approved manufacturers are as follows:

    a. Siemens.
    b. Automated Logic.
    c. Belimo.
    d. Johnson Controls.
    e. Delta.

C. Control Damper Actuators:

1. OA (outside air), RA (return air), and EA (exhaust air) actuators shall be spring return type for safety functions. Individual battery backup or capacitor return is not acceptable. With approval a central battery pack NSV system similar to a UPS system may be used with a battery checking circuit to the DDC automation system. Daily verification of battery performance shall be incorporated in the programming.
2. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within ± 1/21 of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators

which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within ± 2.5%.

3. Stroke: 90 seconds end to end full stroke, 15 seconds return to normal for spring return, field selectable rotational / spring return direction.
4. Rating: NEMA 2 Enclosure.
5. Manual override with field adjustable zero and span.
6. Duty cycle: rated for 65,000 cycles.
7. Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.

D. Miscellaneous Damper Actuators:

1. OA combustion and ventilation air intake and EA damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used. The minimum torque for any actuator shall be 5 N-m.
2. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air and greater than 6 KPa TSP.

E. Air Terminals:

1. Air terminal actuators shall be minimum 5 N-m torque and use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers requirements. Noise level shall not exceed 45dB. Life cycle shall be a minimum of 60,000 cycles and 1.5 million repositions. Actuator Power consumption shall not exceed 4VA.

F. Inlet Vanes Actuators:

1. Inlet vane actuators shall provide at least 150% of the minimum torque specified by the manufacturer as necessary to operate vanes properly. Either direct coupled or gear train with linkages are acceptable as required. The control loop for static control of the actuator shall operate slowly enough to avoid hunting and maintain stable control. See automation system specifications for details.

G. Combination Smoke and Fire Damper Actuators:

1. Actuators shall be connected to the damper section and shall conform to UL 555S specifications. Control requirements shall meet UL K 864 smoke requirements.

H. Control Valve Actuator General Requirements

1. Electric:

a. Motor: Suitable for 120 or 240 volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 125 percent duty cycle. Motors shall have inherent overload protection.

b. Gear Train: Motor output shall be directed to a self-locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.

c. Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure

d. Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.

e. Enclosure: Actuator enclosure shall be a NEMA 4 epoxy coated metal enclosure, and shall have a minimum of two threaded conduit entries.

f. Limit Switches: Travel limit switches shall be UL approved. Switches shall limit actuator in both open and closed positions.

g. Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.

h. Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.

i. Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.

j. Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.

k. Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.

l. Ambient Conditions: Actuator shall be designed for operation from –140 to 150 degrees F ambient with 0 to 100 percent relative humidity.

m. Field selectable direction with field adjustable zero span.

I. Electric Control Valves Actuators 4 inches and larger:

1. The valve actuator shall consist of a permanent split capacitor, reversible type electric motor which drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance of 25 feet, showing output shaft and valve position. Unit shall be mounting directly to the valves without brackets and adapters, or readily adapted to suit all other types of quarter-turn valves.
2. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries shall have UL recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
3. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.

4. The actuator shall have a self-locking gear train which is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with 620 in-lb or more output torque shall have two adjustable factory calibrated mechanical torque limit switches of the single-pole, double-throw type. The motor shall be fitted with thermal overload protection. Motor rotor shaft shall run in ball bearings at each end of motor.
5. For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 105°F.
6. The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as option.
7. Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cut-out protector shall be embedded in the motor windings to limit heat rise to 175°F in a 105°F ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.
8. Materials of Construction: The electric actuator shall have a pressure die-cast, hard anodized aluminum base and cover. The compound gear shall be made of die-cast, hard anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.
9. Torque: Size for minimum 150% of required duty.
10. Potentiometer for providing continuous feedback of actuator position at the controller (for valves specified position feedback).

2.8 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (RIO, PCUs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.

B. It shall be the System Integrator's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, is not designed to work with ‘two-wire’ type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the System

Integrator shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, System Integrator shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy and repeatability equal to, or better than, the accuracy and repeatability listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

F. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge to provide a true linear output signal.

G. Sensors used in energy or process calculations shall be accurate to ±0.10°C over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.

H. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.

Point Type	Accuracy
Outside Air	+/-1%
Chilled/Hot Water	+/-1%
Room Temperature	+/-1%
Duct Temperature	+/-1%
Sensors Used in Energy Water (BTU) or Process Calculations	+/-1%

2.9 TEMPERATURE SENSORS (TS)

A. Sensor range: When matched with A/D converter of PCU/ASC, or SD, sensor range shall provide a resolution of no worse than 0.3 degrees F (0.16 degrees C) (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25 degrees F over five (5) years.

B. Matched Sensors: The following applications shall require matched sensors:

1. Hydronic Temperature Difference Calculations: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants. Sensing element shall be platinum RTD guaranteeing an accuracy of +/- 0.5 percent of span plus 0.1 degrees C.

2. Air Handling Unit Sequencing: Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature. Sensing element shall be platinum RTD guaranteeing an accuracy of +/- 0.5 percent of span plus 0.1 degrees C.

C. Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting, unless noted otherwise. Provide insulated base. Following sensing elements are acceptable:

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.6°F accuracy at calibration point.
2. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable or limited via the IAS.
3. If the manufacture supports provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure.
4. Provide current temperature indication via an LCD or LED readout, where noted.
5. Submit sensor to Architect for aesthetic and finish approval prior to installation.

D. Standard Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated. Sensor probe shall be 316 stainless steel.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3 degrees F accuracy at calibration point
2. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
3. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.
4. Acceptable Manufacturers

    a. Pre-Con, ACI, Honeywell, JCI, Invensys, Siemens, BAPI, Mamac

E. Standard Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated.

1. Sensing element shall be platinum RTD, or thermistor, +/- 0.3 degrees F accuracy at calibration point.
2. Provide capillary supports at the sides of the duct / coil to support sensing elements
3. Acceptable Manufacturers

    a. Pre-Con, ACI, Honeywell, JCI, Invensys, Siemens, BAPI, Mamac

F. Liquid immersion temperature sensor shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15 degrees F.

1. Sensing element (chilled water/glycol systems) shall be platinum RTD +/- 0.2 degrees C measured at 0 degrees C.

G. Pipe Surface-Mount Temperature Sensor: Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as require for resolution indicated in this Section.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4 degrees F accuracy at calibration point.

H. Outside Air Sensors shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in this Section.

1. +/- 0.2 degrees C measured at 0 degrees C.
2. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
3. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
4. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
5. Solar load sensors shall be provided in locations shown. The use of a thermistor combined with a solar compensator is acceptable**.** Provide calibration charts as part of the O&M Manual.

2.10 HUMIDITY TRANSMITTERS

A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be a solid state component using a two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA or 0-10 VDC for a linear proportional output relating to percent of relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

1. Input Range: 0 to 100% RH.
2. Accuracy (% RH): +/- 2 percent between 20-90% RH at 77 degrees F, including hysteresis, linearity, and repeatability.
3. Sensor Operating Range: As required by application.
4. Long Term Stability: Less than 1 percent drift per year.
5. Outside air relative humidity sensors shall be installed in a rain proof perforated cover. The transmitters shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
6. Sensor shall be shipped factory calibrated.
7. Duct type sensing probes shall be constructed of 316 stainless steal and equipped with a neoprene grommet, bushings and mounting bracket.

B. Acceptable Manufacturers: Units shall be Vaisala HM Series, General Eastern, Microline, or Hy-Cal HT Series, Pre-Con, Mamac, BAPI.

2.11 CARBON MONOXIDE SENSORS

A. Materials: Metal Oxide Semiconductor

B. Rating: 5000 sq feet

C. Mounting: Duct and wall mount

D. Range: 0 to 200ppm

E. Output: 0-10vDC, 4-20mA

2.12 NITROGEN DIOXIDE (NO2) SENSORS

A. General: Provide sensors with microprocessor controls.

1. Output signal shall be 4 to 20 mA or 0 to 10 VDC.
2. Accuracy shall be +5 percent of full scale.
3. Provide easily adjustable zero and span adjustments via on board potentiometer.
4. Provide sensor with LED indicators to display normal and alarm conditions.
5. Minimum sensor range for NO2 shall be 0-10 ppm in 0.1 ppm increments.

B. Acceptable Manufacturers: MSA, Vulcain, Sierra Monitor.

2.13 CHLORINE SENSOR (CL) SENSORS

A. General: Provide sensors with microprocessor controls.

1. Output signal shall be 4 to 20 mA or 0 to 10 VDC.
2. Accuracy shall be +5 percent of full scale.
3. Provide easily adjustable zero and span adjustments via on board potentiometer.
4. Provide sensor with LED indicators to display normal and alarm conditions.
5. Minimum sensor range for CL shall be 0-10 ppm in 0.1 ppm increments.

B. Acceptable Manufacturers: MSA Ultima X “PL”, Vulcain, Sierra Monitor.

2.14 CARBON DIOXIDE SENSORS (CO2)

A. General: CO2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.

1. Materials: Molded plastic enclosure
2. Rating: 0 to 5000ppm
3. Mounting: Duct or Wall as indicated
4. Range: 0 to 2000ppm / 0-5000 User selectable
5. Accuracy: +/- 36ppm at 800 ppm and 68 degrees F.
6. Output: 0-10vDC, 4-20mA or alarm relay
7. Stability: 5 percent over 5 years.

B. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall), Pure Choice NOSE Sensor.

2.15 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. General DP performance requirements

1. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
2. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
3. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
4. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible. Provide tubing with rubber or neoprene grommet from panel to expose room conditions when necessary.
5. Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
6. Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.

B. Liquid, Steam and Gas :

1. General: Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc linear output, adjustable span and zero, stainless steel wetted parts.
2. Ambient Limits: –40 to 175 degrees F (-40 to 121 degrees C), 0 to 100% RH.
3. Process Limits: –40 to 400 degrees F (-40 to 205 degrees C).
4. Accuracy: Less than 0.1 percent.
5. Output Damping: Time constant user selectable from 0 to 36 seconds.
6. Non-interactive zero and span adjustments adjustable form the outside cover.
7. Vibration Effect: Less than +/- 0.1 percent of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
8. Electrical Enclosure: NEMA 4, 4X, 7, 9.
9. Approvals: FM, CSA.
10. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa.

C. General Purpose Low Pressure Air (0 – 125 Pa): Generally for each measurement of duct pressure, filter differential pressure or constant volume air velocity pressure measurement where the range is applicable. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following performance requirements.

1. General: Loop powered two-wire differential capacitance cell-type transmitter immune to shock and vibration
2. Switch shall be capable of Automatic Rest
3. Output: Two wire 4-20 mA output with zero adjustment.

4. Overall Accuracy: Plus or minus 0.5 percent of full scale
5. Dead Band: Less than 0.3% of output
6. Repeatability: Within 0.2% of output
7. Linearity: Pluss or Minus 0.2% of span
8. Response: Less than on second for full span input.
9. Temperature Stability: Less than 0.05% of output shift per degree C change.
10. Minimum Range: 0.1 inches w.c.
11. Maximum Range: 10 inches w.c.
12. Housing: Polymer housing suitable for surface mounting.
13. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
14. Range / Span: Select for specified setpoint to be between 25 percent and 75 percent full-scale. Not greater than two time the design space DP
15. Magnehelic Gauges: Provide Dwyer Series 200 Magnehelic Differential Pressure Gauge (or equal) for each DP transmitter. Provide gauge, mounting bracket, ¼ inch aluminum tubing, static pressure tips, and molded plastic vent valves for each gauge connection. Select range for specified recommended filter loading pressure drop to be 75 percent full-scale. For other DP transmitters select range for specified setpoint to be between 25 percent and 75 percent full-scale
16. Acceptable Manufacturers: Units shall be Setra, Modus T30, Veris PX Series, or Dwyer Series 616.

D. Medium to High Air Pressure Applications (125Pa to 2500 Pa) : The pressure transmitter shall match the characteristics defined for low air applications with the modified performance criteria:

1. Zero and Span (% F.S./ Deg C) shall be 0.05% including linearity, hysteresis and repeatability.
2. Accuracy: 1% Full Scale (best straight line)
3. Static Pressure Effect: 0.05% Full Scale (to 700 KPA)
4. Thermal Effects: less then +/- 0.05% Full Scale / Deg C over 5C to 40C when calibrated at 22 deg C.
5. Pressure switches shall be manually reset.

E. General Purpose Low Pressure/Low Differential Air: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered, two-wire differential capacitance cell type transmitter.
2. Output: Two-wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1 percent.
4. Minimum Repeatability: +/- .25 percent of reading.
5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Setra, Modus T30.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25 percent and 75 percent full-scale.

F. VAV Velocity Pressure: Generally for use in variable volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered two-wire differential capacitance cell type transmitter.
2. Output: Two-wire, 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 0.25 percent.
4. Minimum Range: 0 inches w.c.
5. Maximum Range: 1 inch w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Setra.
8. Range: Select for minimum range that will accept the maximum velocity pressure expected.
9. Magnehelic Gauges: Provide Dwyer Series 200 Magnehelic Differential Pressure Gauge (or equal) for each DP transmitter. Provide gauge, mounting bracket, ¼ inch aluminum tubing, static pressure tips, and molded plastic vent valves for each gauge connection. Select range for specified setpoint to be between 25 percent and 75 percent full-scale.

2.16 SPACE STATIC PRESSURE SENSORS

A. Shielded Static Pressure Sensor

1. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber with minimum volume of 48 cubic inches, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
2. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 feet per minute from a radial source.
3. The shielded static sensing devices shall be used for both reference and space pressure sensing.
4. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.

B. Static Pressure Traverse Probe

1. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
2. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
3. The duct static traverse probe shall be of 304 stainless steel construction and (except for 0.75 inches dia. probes with lengths of 24 inches or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of 21.
4. Acceptable Manufacturers: Mamac, STAT-Probe/l, Brandt; B-SSK 8000.

C. Intelligent Static Pressure Sensor: Intelligent sensors using network communications to transmit data and shall meet the following characteristics:

1. Low pressure type (0 to 125 Pa) differential pressure transmitter.
2. Integrated LONWORKS® Neuron controller.
3. FTT LONWorks® network transceiver.
4. Integral power supply for transmitter controller and transceiver.
5. Accuracy: +/- 1% full scale

2.17 AIRFLOW MEASURING STATIONS (AFMS)

A. Air Flow Measuring Stations (thermal dispersion type)

1. Each air flow measuring station shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
c. The airflow rate at each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
d. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
e. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries shall have UL recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
f. Acceptable manufacturers: Ebtron.

2. All sensor probes (thermal dispersion type)

a. Each sensor shall independently determine the airflow rate and temperature at each measurement point.
b. Each sensor shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute and Standards and Technology (NIST).
c. Airflow accuracy shall be ±2% of Reading over the entire operating airflow range.

1) Devices whose accuracy is the combined accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

d. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing)

e. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
f. Each sensor assembly shall not require matching to the transmitter in the field.
g. A single manufacturer shall provide both the airflow measuring probe(s) and transmitter for each measurement location.

3. Duct and plenum probes (thermal dispersion type)

a. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
b. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

1) Insertion mounted through the side or top of the duct.
2) Internally mounted inside the duct or plenum.
3) Standoff mounted inside the plenum.

c. The number of sensor housings provided for each location shall be as follows:

Duct or Plenum Area (sq. ft.)	Total Number of Sensors / Location
<2	4
2 to <4	6
4 to <8	8
8 to <16	12
>=16	16

d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

4. Fan inlet probes (thermal dispersion type)

a. Sensor assemblies shall be mounted on 304 stainless steel housings.
b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
c. Mounting feet shall be constructed of 304 stainless steel.
d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on plans.

5. Transmitters (thermal dispersion type)

a. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display

shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

b. The transmitter shall be capable of field configuration and diagnostics using and on-board pushbutton interface and LCD display.

c. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

1) The transmitter shall use a switching power supply fused and protected form transients and power surges.

2) The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients, and brown-outs.

d. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

e. The operating range for the transmitter shall be -20 to 120°F. The transmitter shall be installed in a location that is protected from weather and water.

f. The transmitter shall be capable of communicating with other devices using LonWorks Free Topology (FTT-10).

g. The airflow measuring station shall be UL listed as an entire assembly.

h. The manufacturer's authorized representative shall review and approve placement and airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting engineer if any measurement locations do not meet the manufacturer's placement requirements.

B. Air Flow Traverse Probes (pressure differential type):

1. Traverse probes shall be a dual manifold, cylindrical, type. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching air flow and without the physical presence of forward projecting sensors into the airstream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm 20^{o}$ in the approaching airstream.

2. Each airflow measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.

3. Each flow measuring station shall be complete with its own dedicated microprocessor with a 4-line, 80 character, Alpha Numeric display and full function key pad. The panel shall be fully programmable and display calculated liters per minute directly on a LED monitor on the panel face.

4. Provide 24 volt single phase power to each flow measuring station.

5. The probes, and placement of the probes, shall provide measurement accuracy within +/- 2 percent of actual velocity. Probes shall be of cylindrical cross Section and shall indicate no more than a +/- 3 percent deviation from the centerline velocity at a yaw angle of 30 degrees.

6. Probes shall be provided with integral mounting plate, 1/4 compression fitting connections, end mounting rod and be suitable to operate in ambient conditions

off 300 degrees F. The probe assemblies shall not have a pressure drop greater than 10 percent of the velocity pressure at the maximum design flow. The probes shall not amplify sound levels in the duct.

7. Submit data indicating the developed differential pressure and pressure loss at the minimum and maximum design flows for each duct location. Provide differential pressure transmitter for measuring velocity, with a range selected to match the velocity of the maximum design flow for the duct served.

   a. Sensor Accuracy: +/- 2.0 percent.
   b. Interchangeability: +/- 0.5 percent.
   c. Velocity Range: 400 to 9000 fpm.
   d. Electronics Accuracy: +/- 0.05 percent.
   e. Temperature Limits: -20 degrees F to 200 degrees F.
   f. Enclosure for Electronics: NEMA 1.
   g. Humidity Limits: 0 to 100% RH (non-condensing).
   h. Material: 304 stainless steel.
   i. Operating Range: Select minimum range to accommodate the expected flow range of the equipment.
   j. The following schedule is the minimum probe quantities across either the width or height of the duct sections where the probes are being inserted:

Insertion Side (inches)	Quantity
6-11	1
12-30	2
31-48	3
48-60	4
61-84	6
85-120	6

C. Acceptable manufacturers

   1. Manufacturer: Tek-Air Model T-FP5000

2.18 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

A. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause on over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves, calibration taps, and a bypass valve contained in a NEMA 1 enclosure.

2.19 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. All pressure sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings.

B. Pressure sensor switch contacts shall be snap action micro-switch type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides and so forth.

C. Differential pressure switches shall be vented to withstand a 50% increase in working pressure without loss of calibration.

D. General Service Auto Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal.

E. General Service Manual Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal.

F. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range and 0 degrees F to 160 degrees F operating temperature range.

2.20 PRESSURE SWITCHES (PS)

A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150 percent of rated pressure.

B. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls.

2.21 TRANSDUCERS

A. Standard Capacity Electronic-to-Pneumatic (E-P) Transducers: E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type:

1. Electrical Power Supply: 24 Vac or 24 Vdc.
2. Pneumatic Air Supply: 30 psig (2.07 bar) maximum.
3. Air Capacity: 1100 scim @ 20 psig (300 cm3/sec @ 1.4 bar).
4. Air Consumption: Zero at steady state.
5. Output Span: 0-20 psig (0-1.4 bar).
6. Input: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, or 3-15 Vdc input.
7. Gauges: Provide with main and branch air gauges
8. Enclosure: Polymer designed for surface or panel mount. Provide with main air and branch air gauges.
9. Air Connections: ¼ inch (6.35 mm) barbed.
10. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
11. Acceptable Manufacturers: RE Technologies Model UCP-522, BEC Controls Corp, MAMAC

B. Electronic-to-Pneumatic (E-P) Transducers: E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type, Phase cut Type:

1. Electrical Power Supply: 24 Vac or 24 Vdc, 100 mA.
2. Accuracy: +/- 1 percent.
3. Feedback: Branch pressure feedback from an on board pressure sensor - VDC Feedback.
4. Override: Manual Potentiometer.
5. Pneumatic Air Supply: 25-30 psig (2.07 bar) maximum.
6. Air Capacity: .5 scim @ 20 psig (300 cm3/sec @ 1.4 bar).
7. Air Consumption: None.
8. Output Span: 3-15 psig factory set field adjustable.
9. Input: 4-20 mA, 0-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-18 Vdc, 0-20V Phase Cut input.
10. Gauges: Provide with main and branch air gauges.
11. Enclosure: NEMA 1. Provide with main air and branch air gauges.
12. Air Connections: ¼ inch (6.35 mm) barbed brass.
13. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
14. Acceptable Manufacturers: TRIATEK CP-3000.

2.22 CURRENT SWITCHES (CS)

A. Current Sensing switch shall be self-powered with solid-state circuitry and a dry contact output. Current sensing switch shall accept over current up to twice its trip range. Clamp-On Design Current Operated Switch (for Constant Speed Motor Status Indication):

1. Range: 2.5 to 135 amps.
2. Trip Point: Adjustable.
3. Switch: Solid state, normally open, 1.0A @ 30VAC/DC.
4. Lower Frequency Limit: 6 Hz.
5. Trip Indication: LED.
6. Approvals: UL, CSA.
7. Max. Cable Size: 350 MCM.
8. Acceptable Manufacturers: Veris Industries H-908.

B. Clamp-on Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938 or RE Technologies RCS 1150.

1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX.

C. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication:

1. Range: 3.5 to 135 Amps.
2. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
3. Switch: Solid state, normally open, 0.1A @ 30VAC/DC.
4. Frequency Range: 35 to 75 Hz.
5. Trip Indication: LED.

6. Approvals: UL, CSA
7. Max. Cable Size: 350 MCM.
8. Acceptable Manufacturers: Veris Industries, Inc. H-904.

D. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable manufacturer shall be Veris Industries, Inc., Model # H934.

E. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

2.23 KW TRANSDUCER

A. KW transducer shall be used in simple power monitoring applications. Transducers shall meet the following criteria.

1. Materials: Encased copper
2. Rating: 600 VAC
3. Mounting: Split Core
4. Range: Up to 2400amps
5. Accuracy: +/- 1%
6. Output: 4-20mA

2.24 CURRENT TRANSFORMERS (CT)

A. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.

1. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
2. The current transformers shall meet the following specifications:

   a. Frequency Limits: 50 to 400 Hz.
   b. Insulation: 0.6 KV Class, 10 KV BIL.
   c. Accuracy: 1% at 10% to 130% of rated current.
   d. Range 1-10 Amps minimum, 20-200 amps maximum
   e. Trip Point adjustable
   f. Output 0-5 VDC

3. Provide a disconnect switch for each current transformer.
4. Protection: 250 A max current.
5. Acceptable Manufacturers: Ohio, Semitronics Technologies Inc., Triad Technologies, EMON, Hawkeye, Continental Control Systems

2.25 OUTDOOR AIR STATIC PRESSURE SENSING TIP

A. Pressure Sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306.

B. Low Air Pressure Surge Dampener: 30-second time constant. Acceptable manufacturer shall be Modus SD030.

2.26 CONTINUOUS LEVEL TRANSMITTERS

A. Capacitance Type:

1. General: Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
2. Output: 4-20 mA.
3. Probe: Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
4. Electrical Enclosure: NEMA 4, 7.
5. Approvals: UL or CSA.
6. Accuracy: +/- 1 percent of calibrated span.
7. Process Connection: MPT or ANSI Flange as required.
8. Acceptable Manufacturers: Drexelbrook, Endress & Hauser.

B. Hydrostatic Pressure:

1. General: Two wire smart d/p cell type transmitter.
2. Output: 4-20 mA or 1 to 5 volt user selectable linear or square root output.
3. Range: Adjustable span and zero.
4. Probe: Stainless steel wetted parts.
5. Environmental Limits: –40 to 250 degrees F (-40 to 121 degrees C), 0 to 100% RH.
6. Accuracy: Less than 0.1 percent of span.
7. Output Damping: Time constant user selectable from 0 to 36 seconds.
8. Vibration Effect: Less than +/- 0.1 percent of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
9. Electrical Enclosure: NEMA 4, 4X, 7, 9.
10. Approvals: FM, CSA.
11. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, and Johnson-Yokagawa.

2.27 MAGNETIC FLOW METER FOR WATER SERVICE

A. General Requirements:

1. Sensor shall be a magnetic flow meter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe.
2. The flow meter shall consist of two (2) elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.

3. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).

    a. Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube.
    b. Output: 4-20 mA.
    c. Flow Tube: Stainless steel.
    d. Electrical Enclosure: NEMA 4, 7.
    e. Approvals: UL or CSA.
    f. Stability: 0.1 percent of rate over six (6) months.
    g. Process Connection: Carbon steel, ANSI 150 LB, size as required.

B. Meter Accuracy:

1. Under the reference conditions of a 68 degrees F media temperature, a 68 degrees F ambient temperature, a +/- 1 percent nominal power supply voltage, 10 diameters up stream and 5 down of straight piping and a fully developed flow profile; the meter must meet the following requirements:
2. Plus or minus 0.8 percent of reading accuracy in the flow range of 1.65 - 33 ft/sec +/- (0.66/Velocity actual feet per second +0.4) percent of reading accuracy in the flow range of 0 - 1.65 feet per second.
3. Meter repeatability shall be +/- 0.1 percent of rate at velocities > 1.65 feet per second.

C. Calibration: The sensor must be calibrated on an internationally accredited (i.e. NAMAS) flow rig with accuracy better than 0.1 percent. Calibration shall be traceable to National Institute of Standard and Technology.

D. Construction:

1. The meter piping material shall be AISI 304 stainless steel.
2. The meter flange and enclosure material shall be carbon steel.
3. The external surface of the sensor is to be treated with at least .006 inches (150 µm) of Corrosion resistant two-component paint.
4. The inner meter piping shall be protected with a neoprene liner or similar liner.
5. The electrode material shall be AISI 316 Ti or better.
6. The sensor be ANSI class 150 pounds.

E. Electronics:

1. The sensor shall contain a SENSOR-PROM, storing calibration and factory default settings, i.e. the identification of the sensor and size.
2. An ISO 9001 approved company shall manufacture the sensor and electronics.
3. As standard, the electronics must be installable directly on the sensor or installable (remote) up to 1500 feet from the sensor as a maximum.
4. With local electronics installation, the electronics shall be able to withstand three (3) feet water submersion for up to 30 minutes.
5. The electronics shall be compatible with the following power specifications:

    a. 15/230 Vac +10 percent to 15 percent 50-60 Hz.

b. The power consumption must be 10 Watts or less independent of meter size.

6. The meter electronics shall be able to produce simultaneous scaleable current and frequency/pulse output. The frequency output shall be linearly proportional to flow rate and scaleable from 0-10 kHz. The pulse output shall be scaleable from 50 to 5000 milliseconds duration, suitable for an electromechanical totalizer in engineering units.
7. The electronics must have an internal totalizer for summation of flow.
8. The output of the electronics must be individually, galvanically isolated with an isolation voltage of more than 500 V.

F. Output:

1. The current signal must be either 0-20 mA or 4-20 mA proportional to the flow velocity.
2. The output current signal must accommodate 20 percent over range without loss in linearity.
3. The electronics shall have an alphanumeric LCD display showing actual flow and totalized flow in engineering units.
4. The display and keyboard must be rotatable so that the display can be viewed regardless of sensor orientation.

G. Error Detection:

1. The electronics must be able to detect the flowing error conditions:

   a. Signal connection between electronics and sensor interrupted.
   b. Loss of current to the coil circuit.
   c. Load on the current output.
   d. Defective electronics.
   e. Defective sensor.
   f. Empty pipe.

2. The electronics must have an Error Log where all error conditions occurring within a period of 180 days are stored.

H. Electronic Replacement Programming:

1. The electronics must be immediately replaceable without the need of cable disconnection or renewed configuration programming.
2. When the supply voltage is applied, the electronics must self configure and display flow without keyboard contact (no programming required).
3. The electronics must be provided with an automatic zero flow setting.
4. The electronics shall be programmable with respect to:

   a. User display options and menu
   b. Setting data
   c. Configuration of outputs
   d. Zero ‘cut-off’ from 0 percent to 9.9 percent of maximum flow.

5. For ease of programming, the electronics shall be programmable away from the meter using the meter Sensor-Prom and a 9 V battery.
6. The electronics shall be suitable for operation in an ambient temperature range of -4 degrees F to 120 degrees F.

I. Acceptable Manufacturers:

1. ABB
2. Engineering Measurements Co. (EMCO MAG 3100 with a model MAG 2500 electronic transmitter and display).
3. Rosemont.
4. Hersey Measurement.
5. Yokogawa Industrial Automation.
6. Endress & Hauser.

2.28 STRAP-ON AQUASTAT

A. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch setpoint shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.

2.29 PNEUMATIC CONTROL COMPONENTS

A. Analog Pressure Gauges: Gauges shall be pneumatic type, minimum 1-1/2 inches (38 mm) in diameter, with white face and black numerals. Surface-mounted gauges shall have chrome plated trim and be a minimum of 2-1/2 inches (64 mm) in diameter.

B. Pneumatic Actuated Pressure Switches (PE) (for 30 psig max pressure control systems): Pressure ranges and sensitivity of PEs shall match control system sequence of operation. Switch operation shall be externally adjustable over the operating pressure range (nominal 0-20 psig, 0 to 138 KPa). PE switches shall be SPDT type, rated for the particular application, and shall be UL listed. PE shall be as manufactured by Penn.

C. Pilot Positioners: Operating span adjustment range is from 3 to 15 psi (21 to 104 kPa), or as required for the actuator being served. Positioner shall be furnished with zero and span adjustments and a mounting bracket for attachment directly to the actuator.

D. Pneumatic Valve/Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

2.30 ELECTRIC CONTROL COMPONENTS

A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley.

B. Electric Solenoid-Operated Pneumatic Valves (EP): EP valves shall be rated for a minimum of 1.5 times their maximum operating static and differential pressure. Valves shall be ported 2-way, 3-way, or 4-way and shall be normally closed or open as required

by the application. EPs shall be sized for minimum pressure drop, and shall be UL and CSA listed. Furnish and install gauges on all inputs of EPs. Furnish an adjustable air pressure regulator on input side of solenoid valves serving actuators operating at greater than 30 psig.

1. Coil Enclosure: Indoors shall be NEMA 1, Outdoors shall be NEMA 3, 4, 7, 9.
2. Fluid Temperature Rating: Valves for compressed air and cold water service shall have 150 degrees F (66 degrees C) minimum rating. Valves for hot water or steam service shall have fluid temperature rating higher than the maximum expected fluid temperature.
3. Acceptable Manufacturers: EP valves shall be as manufactured by ASCO or Parker.
4. Coil Rating: EP valves shall have appropriate voltage coil rated for the application (i.e., 24 VAC, 120 VAC, 24 VDC, etc.).

C. Low Temperature Detector ('Freezestat') (FZ): Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8 inches x 20 feet (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range 15 to 55 degrees F (-9.4 to 12.8 degrees C), factory set at 38 degrees F.

1. Provide one low limit thermostat for each 20 square feet or fraction thereof of coil surface area.
2. Provide Manual reset
3. Sensor shall be DPDT 120/240 volts AC, rated at 10 Amps at 120 volts full load.(4 wire, 2 circuit)

D. High Temperature Detectors ('Firestat') (FS): High temperature detector shall consist of 3-pole contacts, a single point sensor, junction box for wiring connections and gasket to prevent air leakage of vibration noise, triple-pole, with manual reset. Temperature range 25 to 215 degrees F (-4 to 102 degrees C).

E. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150 degrees F (10 to 65 degrees C), and a minimum 10 degrees F fixed setpoint differential.

F. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed contacts, operating temperature range of 50 to 90 degrees F (10 to 32 degrees C), switch rating of 24 Vac (30 Vac maximum), and both manual and automatic fan operation in both the heat and cool modes.

G. Control Relays General:

1. Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
2. Solid State Relays (SSR): Input/output isolation shall be greater than $l0E^9$ ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The

contact life shall be 10 x 10 E^6 operations or greater. The ambient temperature range of SSRs shall be -20 to +140°F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.

3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. System Integrator shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

H. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA 1 enclosure for indoor locations, NEMA 4 for outdoor locations.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:

   a. AC coil pull-in voltage range of +10 percent, -15 percent or nominal voltage.
   b. Coil sealed volt-amperes (VA) not greater than four (4) VA.
   c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
   d. Pilot light indication of power-to-coil and coil retainer clips.
   e. Coil rated for 50 and 60 Hz service.
   f. Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA or approved equal.
   g. Material: Gold Flash
   h. Rating 10 amps at 120-277 VAC
   i. Provide HOA switch except in smoke control applications.

2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 horsepower, and 1/3 horsepower, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or approved equal.
3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
4. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. Freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control drawings for details.

I. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.

J. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall have replaceable fuses in accordance with the NEC. Transformer shall be properly sized for application, and mounted in minimum NEMA 1 enclosure.

1. Transformers shall be manufactured by Westinghouse, Square 'D', or Jefferson.

K. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a NEMA 1 enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type.

L. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley or approved equal.

M. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley or approved equal.

N. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory or approved equal.

O. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley or approved equal.

2.31 THERMOWELLS

A. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and greenfield fitting, except where wells are to be installed under separate contract.

B. Thermowells shall be pressure rated and constructed in accordance with the system working pressure

C. Thermowells and sensors shall be mounted in a threadolet or 12.7 mm NPT saddle and allow easy access to the sensor for repair or replacement.

D. Thermowells shall be constructed of the following materials:

1. Chilled and Hot Water; brass.
2. Steam; 316 stainless steel.

3. Brine (salt solutions): marine grade stainless steel.

2.32 POWER METERS

A. Provide electrical / power metering equipment with the required features for the specified level of metering herein and within division 16. Power meters shall have the following minimum features:

1. Meet ANSI C12.1 and FCC Class B metering standards
2. Accuracy +/- .5%
3. Operating Voltage Range: -80% to 115%
4. Operating Temperature: -30 deg C to 55 deg C.
   Operating Humidity: Up to 90& RH (non-condensing)
5. KWH data shall be stored in non-volatile memory.
6. Meter shall be capable of monitoring single or three phase power as specified.
7. Meter shall have network communications such as Lonworks of Modbus.
8. Meter shall have the ability to record, calculate and transmit the following for each phase.

   a. Power Faults, True RMS Power - Watts (Phase A, Phase B, Phase C, All Phases) ,Reactive Power - VARs (Phase A, Phase B, Phase C, All Phases), Power Factor (Phase A, Phase B, Phase C, All Phases) ,True RMS Energy - Watt-hours (Phase A, Phase B, Phase C, All Phases), Reactive Energy - VAR-hours (All Phases) ,AC Frequency ,Computed RMS Voltage (Phase A, Phase B, Phase C) ,Computed RMS Current (Phase A, Phase B, Phase C), Demand ,Peak Demand

9. Acceptable Manufactures: Continental Control Systems, Veris Industries

2.33 NAMEPLATES

A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 inch thick, black, with white center core, and shall be minimum 1 inch x 3 inch, with minimum ¼ inch high block lettering. Nameplates for devices smaller than 1 inch x 3 inch shall be attached to adjacent surface.

B. Each nameplate shall identify the function for each device.

2.34 TESTING EQUIPMENT

A. System Integrator shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. System Integrator shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/- 0.5 percent accurate, test equipment shall be +/- 0.25 percent accurate over same range).

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with manufacturer's published recommendations.

C. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of the latest edition of the National Electrical Code and all local codes.

D. Main Control Air Piping: All main air piping between the compressors and the control panels shall be copper, run per ASTM B88

E. Branch Control Air Piping: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs; furred walls; or ceilings with no access.

1. Provide copper tubing with maximum unsupported length of three (3) feet for accessible tubing run exposed to view. Terminal single-line connections less than 18 inches length may be copper tubing, or polyethylene tubing run. Tubing exposed to ambient conditions must be properly protected from sunlight and protected from damage.
2. Provide copper tubing for inaccessible tubing, other than in concrete pour. In a concrete pour polyethylene tubing may be used, install in rigid conduit or vinyl-jacketed polyethylene tubing. Install in galvanized rigid steel conduit at all exterior locations. Install in PVC Schedule 40 conduit if encased in concrete.
3. Polyethylene tubing may be used in control panels provided it is run in a neat and orderly fashion, bundled where applicable, properly supported and installed in a neat and workman like manner. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion.
4. Pressure test control air piping at 30 psi (207 kPa) for 24 hours. Test fails if more than 2 psi loss occurs.
5. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

F. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side

up. Where vertical stem position is not possible or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

G. Averaging Temperature Sensors: Cover no more than two square feet per linear foot of sensor length except where indicated. Generally, where flow is sufficiently homogeneous/adequately mixed at sensing location, consult Engineer for requirements.

H. Airflow Measuring Stations: Install per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

I. Fluid Flow Sensors: Install per manufacturer's recommendations in an unobstructed straight length of pipe.

J. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

K. Water Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

L. Pipe Surface Mount Temperature Sensors: Install with thermally conductive paste at pipe contact point. Where sensor is to be installed on an insulated pipe System Integrator shall neatly cut insulation install sensor, repair or replace insulation and vapor barrier and adequately seal vapor barrier.

M. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

N. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

O. Supply Duct Pressure Transmitters:

1. General: Install pressure tips with at least four (4) 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install static pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
2. VAV System 'Down-Duct' Transmitters: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system.

P. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

END OF SECTION 17830