Sidock Group, Inc.
ENGINEERS • ARCHITECTS • CONSULTANTS • PROJECT MANAGERS

Bid Addendum #3

Project: Taylor Animal Shelter – Remodel & Expansion
Location: 25555 Northline Road, Taylor MI 48180
Professional Record: Sidock Group inc.
Sidock Group project number: 22712.A
Date: 04-20-2024

This form identifies an Addendum to Bidding Documents, and incorporates interpretations or clarifications, modifications, and other information into the Bidding Documents. Addenda will be numbered by the Professional of Record and distributed through the City of Inkster.

Addendum Items:

Clarifications:

- Re-issue Mechanical Specification Sections 21, 22, & 23:
  - Sections 21, 22, & 23 have been reissued as needed to address HVAC system questions.
  - These attached sections shall replace those that were included within the original project manual.
  - These sections address bidder questions related to:
    - sequence of operations
    - BMS control systems
    - Packaged units with all operating controls
    - VAV's with controls

- Re-issue Door Hardware Specification Section 87100:
  - Section 87100 has been reissued as needed to address door hardware clarification questions.
  - This attached section shall replace that which is included within the original project manual.

- Re-issue of Plumbing sheets PD-110, P-112 and P-113
  - Plumbing sheets have been re-issued to further clarify the fire protection system scope of work. See clouded items on attached drawings.
  - These attached drawings shall replace those issued within the original bid documents.

Bidder Questions:

- Question: Who is the current fire alarm company?

  - Response: These is not a current company. The City self-monitors the system.

- Question: Is the intention to install the specified poly-isocyanurate insulation under the EPDM roofing system?
  - Response: Yes.

- Question: Is the intention to install a 45 mil EPDM system with the maximum warranty (less than 20 years) or to install a 60 mil EPDM system with a 20-year warranty?
  - Response: Provide 60 mil EPDM with 20-year warranty.

- Question: Is lightning protection required?
  - Response: No.

- Question: Will an alternate material be accepted for EPDM roofing in the form of Versico EPDM?
  - Response: Yes.

- Question: Who is to provide the main distribution panel?
  - Response: General Contractor.

- Question: Will an alternate material be accepted for epoxy flooring that is not static disipated? A non-static disipated product would be noticably less expensive.
  - Response: Yes.

- Question: Is the metal lettering shown in A-200/17 included in the signage allowance? If not, who is to provide / install?
  - Response: Yes, included within allowance.

- Question: Is a flow test to be incorporated into the General Contractor's quote for new fire suppression requirements?
  - Response: Yes.

- The carpet per the drawings is noted to be carpet tile, while specifications call for a broadloom (12 ft rolls). Is the drawing or specifications to dictate construction?
  - Response: Drawing shall dictate.

- Question: The hardware specifications list the locks as both cylindrical or mortise. Please clarify.
  - Response: Locks are to be cylindrical.

- Question: Can a specification be provided for the walk off mat shown on A-903/7?
  - Response: Walk off mat to be carpet tile style set within depth of surrounding floor tile. Product to be Super Nop 52 tile by matinc.com or equivalent.

- Question: Can a write up be provided to give additional information on the thickness, base material, reinforcing, etc of the asphalt and concrete paving?
  - Response 1 Asphalt: (from base up) 8” 21AA aggregate bae / 2.5” MDOT HMA 4E ML (tier II) / Bond coat – SS IH 0.10 GAL/SQ. YD. / 1.5” MDOT HMA 5E ML (tier II)

  - Response 2 Concrete: (from base up) Proof-rolled sub base / 4" MDOT Class II / Class A Concrete (3500 PSI min.)

- Question: Page S-001; special notes. Please clarify who is responsible for tests/inspections?
  - Response: General contractor shall be responsible for tests and inspections.

- Question: For the dog kennels, it appears there was an integral epoxy cove installed on existing. Are these coves to be prepped and repaired to be recoated with the new material?
  - Response: Yes, these coves shall be prepped and repaired to be recoated.

Issued by: Wayne Dutton, Architectural Project Manager, Sidock Group inc.

END OF DOCUMENT

SECTION 21 05 00

COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 SUMMARY

A. The existing building is protected by a system of automatic sprinklers. The scope of this project shall include the design and installation of a new fire protection system to cover the building addition and the modification of the existing system to suit the new layout. Design and installation shall be in accordance with the requirements of NFPA 13 - 2016 for an Ordinary Hazard, Group 1 Classification. The Fire Protection Contractor shall be responsible for the entire system design, approval and installation and shall submit to the Architect/Engineer for record design drawings and Hydraulic Calculations bearing the approval of the local fire authority.

B. Section includes fire department connections; and Sprinkler System Supervision and Alarms system; including firestopping of sprinkler system components.

C. System shall be designed and built by the fire protection contractor. Drawings and specifications are guides only to outline the performance requirements.

D. Coordination with the Fire Alarm Contractor and Electrical Contractor is required.

1.2 SYSTEM DESCRIPTION

A. Sprinkler System: Conform to the following criteria:
   1. Design system to NFPA 13 - 2016 in accordance with the 2015 International Fire Code.
   2. System performance to achieve NFPA 13 Ordinary Hazard, Group 1 occupancy requirements.
   3. Comply with UL Standards.

B. Firestopping Materials: Comply with requirements of Section 07 84 00 - Firestopping.

C. Coordination with the Fire/Sprinkler Alarm system specified in Section 28 31 00 Fire Alarm & Sprinkler Alarm Systems.

1.3 SUBMITTALS

A. Shop Drawings: Indicate detailed, pipe layout, supports, components, accessories, sizes, and hydraulic calculations.

B. Product Data: Submit data for pipe materials used, valves, manufacturer's catalog sheet for equipment indicating rough-in size, finish, accessories, and capacity.

C. Manufacturer's Certificate: Certify system has been tested and meets or exceeds code requirements.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of sprinkler heads.

B. Operation and Maintenance Data: Submit description of components of system, servicing requirements, record drawings, inspection data, and parts lists.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with:
   1. Sprinkler Systems: NFPA 13 - 2016 and the 2015 International Fire Code - Chapter 9.

B. Design fire suppression system under direct supervision of Professional Engineer or NICET III certified engineering technologist experienced in design of this Work and licensed in State of Michigan.

1.6 WARRANTY

A. Furnish one year manufacturer warranty for fire protection system.

PART 2 PRODUCTS

2.1 PIPE AND TUBE

A. Manufacturers:
   1. Wheatland.
   2. American Tube.
   3. Bull Moose.
   4. Substitutions: Permitted.

B. Steel Pipe: ASTM A53/A53M, Grade B, ASTM A135, or ASME B36.10M, Schedule 10 or 40 black.
   1. Steel Fittings: ASME B16.9, wrought steel, butt welded; ASME B16.25, butt weld ends; ASTM A234/A234M, wrought carbon steel and alloy steel; ASME B16.5, steel flanges and fittings; ASME B16.11, forged steel socket welded and threaded.
   2. Cast Iron Fittings: ASME B16.1, flanges and fittings; ASME B16.4, threaded fittings.
   3. Malleable Iron Fittings: ASME B16.3, threaded type; ASTM A47/A47M.
   4. Mechanical Grooved Couplings: Malleable iron housing, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers.

C. Steel Pipe: ASTM A135 Grade A, ULC threadable thin wall, black.
   1. Cast Iron Fittings: ASME B16.1, flanges and fittings; ASME B16.4, threaded fittings.
   2. Malleable Iron Fittings: ASME B16.3 threaded type. ASTM A47/A47M.

D. Copper Tubing: ASTM B75 (ASTM B75M), ASTM B88 (ASTM B88M), or ASTM B251 (ASTM B251M), Type M or L drawn.
   1. Fittings: ASME B16.18, cast bronze, or ASME B16.22, wrought copper and bronze, solder joint, pressure type.
   2. Joints: AWS A5.8, silver braze. ASTM B32, Alloy Grade Sb5 tin-antimony solder.

3. Mechanical Grooved Couplings: Ductile iron housing with alkyd enamel paint coating clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers.

E. Cast Iron Pipe: AWWA C151.
1. Fittings: AWWA C110, standard thickness.
2. Joints: AWWA C111, rubber gasket with 3/4 inch (19 mm) diameter rods.
3. Mechanical Grooved Couplings: Malleable iron housing, "C" shaped composition sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

2.2 GATE VALVES

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Up to and including 2 inches (50 mm): Bronze body and trim, rising stem, hand wheel, solid wedge or disc, threaded ends.

C. Over 2 inches (50 mm): Iron body, bronze trim, rising stem pre-grooved for mounting tamper switch, hand wheel, OS&Y, solid bronze or cast iron wedge, flanged or grooved ends.

2.3 BUTTERFLY VALVES

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Bronze body, stainless steel disc, resilient replaceable seat, threaded ends, extended neck, hand wheel and gear drive and integral indicating device , and built-in tamper switch.

C. Iron body, iron or bronze disc, EPDM seat, wafer, lug, or grooved ends, extended neck, hand wheel and gear drive, integral indicating device, and internal or external tamper switch.

2.4 CHECK VALVES

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Up to and including 2 inches (50 mm): Bronze body and swing disc, rubber seat, threaded ends.

C. Over 2 inches (50 mm): Iron body, bronze trim, swing check with rubber disc, renewable disc and seat, grooved ends with automatic ball check.

D. 4 inches (100 mm) and Over: Iron body, bronze disc with stainless steel spring, resilient seal and grooved or flanged ends.

2.5 DRAIN VALVES

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Bronze compression stop with nipple and cap or plug.

C. Brass ball valve with nipple and cap or plug.

2.6 SPRINKLERS

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Suspended Ceiling Type: Semi-recessed pendant type with chrome plated finish, and matching escutcheon.

C. Exposed Area Type: Standard upright type with brass finish.

D. Sidewall Type: Semi-recessed horizontal sidewall type chrome plated finish with matching escutcheon.

E. Guards: Finish to red or chrome as required.

F. Match products in the existing Medical Center.

2.7 SPRINKLER PIPING SPECIALTIES

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Wet Pipe Sprinkler Riser Valve: Check type valve with drain and pressure gauge.

C. Electric Alarm: Electrically operated red enameled 8 inch bell with weather proof back box.

D. Water Flow Switch: Vane type switch with two contacts.

2.8 FIRE DEPARTMENT CONNECTION

A. Furnish materials in accordance with NFPA 13 - 2016 and the 2015 Michigan Plumbing Code.

B. Type: Surface mounted wall type with brass finish. Threads to match Fire Department requirements.

C. Outlets: Two way with thread size to suit fire department hardware; threaded dust cap and chain of matching material and finish.

D. Drain: 1/2 inch automatic drip, to outside or drain.

E. Label: "Sprinkler - Fire Department Connection.” (Red Aluminum Plate).

2.9 FIRESTOPPING

A. Firestopping Materials: Comply with requirements of Section 07 84 00.

B. Furnish materials in accordance with the 2015 Michigan Building Code and 2015 International Fire Code.

C. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.

2.10 FIRESTOPPING ACCESSORIES

A. Installation Accessories: Comply with requirements of Section 07 84 00.

2.11 SPRINKLER SYSTEM SUPERVISION AND ALARMS (BY ELECTRICAL OR FIRE ALARM CONTRACTOR).

A. A complete fire alarm system is not required for this project. Smoke alarms are required in sleeping areas.

B. Provide Sprinkler Alarm and supervision in accordance with the 2015 International Fire Code Section 903.4 and specification Section 28 31 00 – Fire & Sprinkler Alarm Systems.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance NFPA 13 - 2016 and the 2015 International Fire Code.

B. Ream pipe and tube ends to full inside diameter. Remove burrs and bevel plain end ferrous pipe.

C. Remove scale and foreign material, inside and outside, before assembly.

D. Install sleeves where penetrating footings, floors, or walls. Seal pipe and sleeve penetration to maintain fire resistance equivalent to fire separation of footings, floors, or walls.

E. Install pipe runs to minimize obstruction to other work. Offset around ductwork.

F. Install piping in concealed spaces above finished ceilings.

G. Install gate or butterfly valves for shut-off or isolating service.

H. Install drain valves at main shut-off valves, low points of piping and apparatus.

I. Connect system to water source ahead of domestic water connection with double check valve or reduced pressure back flow preventer assembly. Plumbing Contractor to install and test. Fire Protection Contractor to provide.

J. Install heads to coordinate with reflected ceiling plan. Center in two directions in ceiling tiles.

K. Protection:
   1. Apply temporary tape or paper cover to sprinkler heads to protect from painting.
   2. Protect concealed sprinkler head cover plates from painting.
   3. Painting Contractor to remove protection after completion of painting.

L. Install drain piping from tank to nearest floor drain.

M. Interface sprinkler system with building control system. (By Electrical Contractor).

N. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent Siamese connectors to allow full swing of fire department wrench handle.

O. Flush entire piping system of foreign matter.

P. Hydrostatically test entire system. Schedule test to be witnessed by Fire Marshall, or authority having jurisdiction, and Owner's insurance underwriter.

3.2 INSTALLATION - FIRESTOPPING

A. Firestopping Materials: Comply with requirements of Section 07 84 00.

END OF SECTION

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Identification for Plumbing Piping and Equipment.
2. Sleeves.
3. Mechanical sleeve seals.
4. Formed steel channel.
5. Firestopping relating to plumbing work.
6. Firestopping accessories.
7. Coordination with requirements for commissioning specified in Section 01 91 00 – Commissioning.

1.2 SYSTEM DESCRIPTION

A. Firestopping Materials: Comply with requirements of Section 07 84 00 - Firestopping.

1.3 SUBMITTALS

A. Shop Drawings: Submit for piping and equipment identification list of wording, symbols, letter size, and color coding for pipe identification and valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

B. Product Data for Pipe and Equipment Identification: Submit for mechanical identification manufacturers catalog literature for each product required.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with 2015 Michigan Plumbing Code

PART 2 PRODUCTS

2.1 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

A. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

B. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light background color.

C. Plastic Tags: Laminated three-layer plastic with engraved black letters on light background color, minimum 1-1/2 inches (38 mm) diameter.

D. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener. Color and Lettering: Conform to ASME A13.1.

E. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings. Color and Lettering: Conform to ASME A13.1.

F. Plastic Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil (0.10 mm) thick, manufactured for direct burial service.

2.2 SLEEVES

A. Sleeves for Pipes through Non-fire Rated Floors: 18 gage (1.2 mm) thick galvanized steel.

B. Sleeves for Pipes through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage (1.2 mm) thick galvanized steel.

C. Sealant: Acrylic or Silicone; refer to Section 07 90 00.

2.3 MECHANICAL SLEEVE SEALS

A. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.4 FORMED STEEL CHANNEL

A. Manufacturers:
   1. Allied Tube & Conduit Corp.
   2. B-Line Systems
   3. Unistrut Corp.
   4. Substitutions: Permitted.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

C. Product Description: Galvanized 12 gage (2.8 mm) thick steel. With holes 1-1/2 inches (38 mm) on center.

2.5 FIRESTOPPING

A. Firestopping Materials: Comply with requirements of Section 07 84 00.

B. Furnish materials in accordance with the 2015 Michigan Building Code.

2.6 FIRESTOPPING ACCESSORIES

A. Installation Accessories: Comply with requirements of Section 07 84 00.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify openings are ready to receive sleeves.

3.2 INSTALLATION - PIPING AND EQUIPMENT IDENTIFICATION

A. Install plastic nameplates with adhesive.

B. Install plastic tags with corrosion resistant metal chain.

3.3 INSTALLATION - SLEEVES

A. Exterior watertight entries: Seal with mechanical sleeve seals.

B. Set sleeves in position in forms. Provide reinforcing around sleeves.

C. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

D. Extend sleeves through floors 1 inch (25 mm) above finished floor level. Caulk sleeves.

E. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing or firestopping insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

F. Install chrome plated steel escutcheons at finished surfaces.

3.4 INSTALLATION - FIRESTOPPING

A. Firestopping Materials: Comply with requirements of Section 07 84 00.

END OF SECTION

SECTION 22 07 00

PLUMBING INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Plumbing piping insulation, jackets and accessories.
   2. Plumbing equipment insulation, jackets and accessories.

1.2 SUBMITTALS

A. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

B. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.

C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.3 QUALITY ASSURANCE

A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84

B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.

C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.

D. Perform Work in accordance with the 2015 Michigan Plumbing Code.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature before, during, and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Manufacturers for Glass Fiber and Mineral Fiber Insulation Products:
   1. CertainTeed.
   2. Knauf.
   3. Johns Manville.
   4. Owens-Corning.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

2.2 PIPE INSULATION

A. Glass Fiber Insulation shall be ANSI/ASTM C547; k value of 0.24 at 75^0F; non-combustible and used on domestic hot and cold water lines, roof drains.
   1. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.

2.3 PIPE INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Piping 1-1/2 inches diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.

C. Piping 2 inches diameter and larger: Wood insulation saddle, hard maple. Inserts length: not less than 6 inches long, matching thickness and contour of adjoining insulation.

D. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.

E. Adhesives: Compatible with insulation.

2.4 EQUIPMENT INSULATION

A. Flexible Mineral Fiber blanket shall be ASTM C553; k value of 0.24 at 75^0F; 2.0 lb/cu ft density and used on air separators. The thickness shall be not less than 1”.

B. Rigid Mineral Fiber board shall be ASTM C612; k value of 0.24 at 75^0F; 6.0 lb/cu ft density and used on domestic hot water storage tanks. The thickness shall be not less than $1^1/_2$”.

C. Cellular glass shall be ASTM C552; k value of 0.35 at 75^0F; 8.0 lb/cu ft density.

2.5 EQUIPMENT INSULATION JACKETS

A. PVC Plastic Equipment Jacket:
   1. Product Description: ASTM D1785, sheet material, off-white color.
   2. Service Temperature Range: -40^OF to 150^0F.
   3. Water Vapor Transmission: ASTM E96/E96M; 0.002 perm-inches.
   4. Thickness: 10 mil (0.25 mm).
   5. Connections: Pressure sensitive color matching vinyl tape.

B. Vapor Retarder Jacket:
   1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.
   2. Water vapor transmission: ASTM E96/E96M; 0.02 perm-inches.

2.6 EQUIPMENT INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Adhesives: Compatible with insulation.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify piping and equipment has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.

B. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 84 00 for penetrations of assemblies with fire resistance rating greater than one hour.

C. Piping Systems Conveying Fluids Below Ambient Temperature:
   1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
   2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
   3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

D. Glass Fiber Board Insulation:
   1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
   2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
   3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.

E. Hot Piping Systems less than 140^0F:
   1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
   2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
   3. Do not insulate unions and flanges at equipment, but bevel and seal ends of insulation at such locations.

F. Inserts and Shields:
   1. Piping 1-1/2 inches diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.

2. Piping 2 inches diameter and Larger: Install insert between support shield and piping and under finish jacket.
   a. Insert Configuration: Minimum 6 inches (150 mm) long, of thickness and contour matching adjoining insulation; may be factory fabricated.
   b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.
3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.

G. Insulation Terminating Points:
   1. Condensate Piping: Insulate entire piping system and components to prevent condensation.

H. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.

3.3 INSTALLATION - EQUIPMENT

A. Factory Insulated Equipment: Do not insulate.

B. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

C. Equipment Containing Fluids Below Ambient Temperature:
   1. Insulate entire equipment surfaces.
   2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
   3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
   4. Finish insulation at supports, protrusions, and interruptions.

D. Equipment Containing Fluids 140^0F or less:
   1. Do not insulate flanges and unions, but bevel and seal ends of insulation.
   2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
   3. Finish insulation at supports, protrusions, and interruptions.

E. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.

F. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

3.4 SCHEDULES

A. Water Supply Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches (mm)
Domestic Hot Water Supply and Recirculation	P-1	1-1/4 inches (32 mm) and smaller 1-1/2 inches (40 mm) and larger	0.5 (13) 1.0 (25)
Domestic Cold Water	P-1	1-1/4 inches (32 mm) and smaller 1-1/2 inches (40 mm) and larger	0.5 (13) 1.0 (25)

B. Drainage Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches (mm)
Sanitary Sewer Piping (horizontal and vertical above ground within building when PVC piping is used)	P-1	All sizes	0.5 (13)

C. Equipment Insulation Schedule:

EQUIPMENT	INSULATION TYPE	INSULATION THICKNESS inches (mm)
Domestic Hot Water Storage Tanks	E-1	1.5 (40)

END OF SECTION

SECTION 221000
PLUMBING PIPING AND PUMPS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Pipe hangers and supports.
2. Pipe and pipe fittings.
3. Valves.
4. Piping specialties.
5. Plumbing drainage specialties.
6. Plumbing supply specialties.
7. Pumps.
8. Coordination with requirements for commissioning as specified in Section 01 91 00 – Commissioning.

1.2 SUBMITTALS

A. Product Data:
1. Pipe Hangers and Supports: Submit manufacturers catalog data including load carrying capacity.
2. Valves: Submit manufacturers catalog information with valve data and ratings for each service.
3. Plumbing drainage specialties: Submit manufacturers catalog information with sizes, capacities, rough-in requirements, service sizes, and finishes.
4. Plumbing supply specialties: Submit manufacturers catalog information with sizes, capacities, rough-in requirements, service sizes, and finishes.
5. Pumps: Include capacities, pump curves, equipment performance, and electrical characteristics.

B. Pipe Hangers and Supports: Design data, indicate pipe sizes, load carrying capacity of trapeze, multiple pipe, and riser support hangers.

C. Manufacturer's Installation Instructions: Submit installation instructions for material and equipment.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit spare parts lists and maintenance procedures.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with the 2015 Michigan Plumbing Code.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Manufacturers:
   1. Carpenter & Paterson Inc.
   2. DecoShield Systems Inc.
   3. Globe Pipe Hanger Products Inc.
   4. Substitutions: Permitted.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

C. Conform to ASME B31.9, ASTM F708, MSS SP 58, MSS SP 69, or MSS SP 89.

D. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (13 to 38 mm): Malleable iron or Carbon steel, adjustable swivel, split ring.

E. Hangers for Pipe Sizes 2 inches (50 mm) and Over: Carbon steel, adjustable, clevis.

F. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

G. Wall Support for Pipe Sizes to 3 inches (75 mm): Cast iron hook.

H. Wall Support for Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp.

I. Vertical Support: Steel riser clamp.

J. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

K. Copper Pipe Support: Copper-plated, carbon-steel adjustable, ring.

2.2 PIPES AND TUBES

A. Sanitary Sewer Piping, Buried Within 5 Feet (1500 Mm) of Building and Sanitary Sewer Piping, above Grade:
   1. PVC Pipe: ASTM D2665 or ASTM D3034 SDR 26, polyvinyl chloride (PVC) material.
      a. Fittings: PVC, ASTM D2665 or ASTM D3034.
      b. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

B. Water Piping, Buried Within 5 Feet (1500 Mm) of Building:
   1. Ductile Iron Pipe: AWWA C151 with ductile iron fittings rubber gasket joints and 3/4 inch (19 mm) diameter rods.

C. Water Piping, above Grade:
   1. Copper Tubing: ASTM B88 (ASTM B88M), Type M, or L, drawn, with cast brass or wrought copper fittings and Grade 95TA solder joints.
   2. Galvanized Steel Pipe (Cold Water Only Sizes 4 inch (100 mm) and Larger): ASTM A53/A53M, Grade B, Schedule 40 with cast iron fittings and grooved mechanical couplings.

D. Storm Water Piping, Buried Within 5 Feet (1500 Mm) of Building and Storm Water Piping, above Grade:
   1. PVC Pipe: ASTM D2665 or ASTM D3034 SDR 26, polyvinyl chloride (PVC) material.
      a. Fittings: PVC, ASTM D2665 or ASTM D3034.
      b. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

E. Equipment Drains and Overflows:

1. Steel Pipe: ASTM A53/A53M, Grade B, Schedule 40 black steel, malleable iron or forged steel fittings, threaded or welded joints.
2. Copper Tubing: ASTM B88 (ASTM B88M), Type M, or L, drawn, cast brass, wrought copper or mechanically extracted fittings, lead free solder joints.
3. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26, PVC fittings, solvent weld joints.

F. Flue and Combustion Air Piping:
1. PVC Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC) material.
   a. Fittings: ASTM D2466, Schedule 40, PVC.
   b. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement. Prime joints with a contrasting color.
2. PVC Pipe: ASTM D1785, Schedule 80, polyvinyl chloride (PVC) material.
   a. Fittings: ASTM D2467, Schedule 80, PVC.
   b. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement. Prime joints with a contrasting color.
3. CPVC Pipe: ASTM F441/F441M, Schedule 40, chlorinated polyvinyl chloride (CPVC) material.
   a. Fittings: ASTM F438, CPVC, Schedule 40, socket type.
   b. Joints: ASTM D2846/D2846M, solvent weld with ASTM F493 solvent cement. Prime joints with a contrasting color.

2.3 VALVES

A. Manufacturers:
1. American Valve.
2. Red-White Valve Corp.
3. Substitutions: Permitted.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

C. For drinking water service, provide valves complying with NSF 61.

D. Gate Valves:
1. Up to 2 inches (50 mm): Bronze body, bronze trim, non-rising stem, hand wheel, inside screw, double wedge disc, soldered or threaded.
2. Over 2 inches (50 mm): Iron body, bronze trim, rising stem, hand wheel, OS&Y, solid wedge, flanged or grooved ends.

E. Ball Valves:
1. Up to 2 inches (50 mm): Bronze or stainless steel one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.
2. Over 2 inches (50 mm): Cast steel flanged body, chrome plated steel ball, Teflon seat and stuffing box seals and lever handle.

F. Plug Valves:
1. Up to 2 inches (50 mm): Bronze body, bronze tapered plug, non-lubricated, Teflon packing, threaded ends.
2. Over 2 inches (50 mm): Cast iron body and plug, pressure lubricated, Teflon packing, flanged ends.

G. Butterfly Valves:
1. 2 inches (50 mm): Bronze body, stainless steel disc, resilient replaceable seat, threaded ends, extended neck, 10-position lever handle.

2. Over 2 inches (50 mm): Iron body, chrome plated iron disc, resilient replaceable seat, wafer or lug ends, extended neck, 10 position lever handle.

H. Swing Check Valves:
1. Up to 2 inches (50 mm): Bronze body and swing disc, solder or threaded ends.
2. Over 2 inches (50 mm): Iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

I. Spring Loaded Check Valves:
1. Iron body, bronze trim with threaded, wafer or flanged ends and stainless steel spring with renewable composition disc.

J. Relief Valves:
1. Bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated capacities ASME certified and labeled.

2.4 PIPING SPECIALTIES

A. Flanges, Unions, and Couplings:
1. Pipe Size 2 inches (50 mm) and Under: Malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
2. Pipe Size Over 2 inches (50 mm): Forged steel flanges for ferrous piping; bronze flanges for copper piping; preformed neoprene gaskets.
3. Grooved and Shouldered Pipe End Couplings: Malleable iron housing, C-shape elastomer composition sealing gasket, steel bolts, nuts, and washers.
4. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

B. Strainers:
1. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
2. Size 2 inches (50 mm) and Under: Threaded brass or iron body for 175 psig (1,200 kPa) working pressure, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.
3. Size 2-1/2 inch (65 mm) to 4 inch (100 mm): Flanged iron body for 175 psig (1,200 kPa) working pressure, Y pattern with 3/64 inch (1.2 mm) stainless steel perforated screen.
4. Size 5 inch (125 mm) and Larger: Flanged iron body for 175 psig (1,200 kPa) working pressure, basket pattern with 1/8 inch (3.2 mm) stainless steel perforated screen.

C. Flexible Connectors:
1. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
2. Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches (230 mm) long with copper tube ends; for maximum working pressure 500.

2.5 PLUMBING DRAINAGE SPECIALTIES

A. Floor Drains:
1. Manufacturers:
a. Watts FD-100-A and FD-100-L.
b. Substitutions: Permitted.
2. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
3. Floor Drain (FD-1): Epoxy coated cast iron two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer.

B. Cleanouts:
1. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

2. Finished Floor: Lacquered cast iron body with anchor flange, reversible clamping collar, and adjustable nickel-bronze round scored cover in service areas and round depressed cover to accept floor finish in finished floor areas.
3. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.

2.6 PLUMBING SUPPLY SPECIALTIES

A. Backflow Preventers:
1. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
2. Reduced Pressure Backflow Preventers: ASSE 1013; bronze body with bronze internal parts and stainless steel springs; two independently operating, spring loaded check valves; pressure relief valve located between check valves; third check valve opens under back pressure in case of diaphragm failure; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.
3. Double Check Valve Assemblies: ASSE 1015 or AWWA C510; bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.

B. Water Hammer Arrestors:
1. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
2. Stainless steel construction, bellows or Copper construction, piston type To PDI WH 201, pre-charged suitable for operation in temperature range -100 to 300 degrees F (-73 to 149 degrees C) and maximum 250 psi (1700 kPa) working pressure.

C. Thermostatic Mixing Valves:
1. Manufacturers:
   a. Delta: R2300-MIX
   b. Substitutions: Permitted.
2. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
3. With check valve, volume control shut-off valve on outlet, stem type thermometer on outlet, strainer stop check on inlet, mounted in lockable cabinet of 16 gage (1.5 mm) prime coated steel.
4. Conform to ASSE 1070 to temper water to maximum 110 degrees F (43 degrees C).

D. Hose Bibbs/Hydrants:
1. Manufacturers:
   a. Woodford Model B67
   b. Substitutions: Permitted.
2. Furnish materials in accordance with the 2015 Michigan Plumbing Code.
3. Wall Hydrant: Non-freeze, self-draining type with chrome plated, lockable recessed box, hose thread spout, removable key, and vacuum breaker.

2.7 IN-LINE CIRCULATOR PUMPS

A. Manufacturers:
1. Taco In-Line Circulator
2. Substitutions: Permitted.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

C. Construction: Bronze casing, bronze impeller, alloy steel shaft with integral thrust collar and two oil-lubricated bronze-sleeve bearings and mechanical seal.

2.8 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Electrical characteristics.
   1. 120 volts, single phase, 60 Hz.

B. Disconnect Switch: Factory mount in control panel.

2.9 MOTORS

A. Furnish materials in accordance with the 2015 Michigan Electrical Code.

B. Motor Type: NEMA MG 1.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavate.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside piping before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.3 INSTALLATION - INSERTS

A. Install inserts for placement in concrete forms.

B. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.4 INSTALLATION - PIPING SYSTEMS

A. Install dielectric connections wherever jointing dissimilar metals.

B. Install unions downstream of valves and at equipment or apparatus connections.

C. Route piping parallel to building structure and maintain gradient.

D. Install piping to maintain headroom. Group piping to conserve space. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

G. Sleeve pipe passing through partitions, walls and floors.

H. Install piping system allowing clearance for installation of insulation and access to valves and fittings.

I. Install identification on piping systems including underground piping. Refer to Section 22 05 00.

J. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

3.5 INSTALLATION - VALVES

A. Install valves with stems upright or horizontal, not inverted.

B. Install gate, ball, or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.

C. Install ball, or butterfly valves for throttling, bypass, or manual flow control services.

D. Provide lug end butterfly valves adjacent to equipment when functioning to isolate equipment.

E. Install spring loaded check valves on discharge of pumps.

F. Install plug valves for throttling service. Install non-lubricated plug valves only when shut-off or isolating valves are also installed.

G. Install 3/4 inch (20 mm) gate or ball drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest drain.

3.6 INSTALLATION - PIPING SPECIALTIES

A. Provide drain and hose connection with valve on strainer blow down connection.

B. Test backflow preventers in accordance with ASSE 5013.

C. Install Work in accordance with the 2015 Michigan Plumbing Code.

3.7 INSTALLATION - PLUMBING SUPPLY PIPING

A. Install water piping in accordance with ASME B31.9.

B. Excavate and backfill in accordance with Section 31 20 00.

C. Establish elevations of buried piping outside the building to obtain not less than 5 ft of cover.

D. Provide support for utility meters in accordance with requirements of utility companies.

E. Slope water piping and arrange to drain at low points.

F. Install piping from relief valves, back-flow preventers and drains to nearest floor drain.

G. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to lavatories and sinks.

H. Provide water service complete with approved reduced pressure or double check back-flow preventer and water meter with by-pass valves, pressure reducing valve, and sand strainer.

I. Install flow controls in water circulating systems as indicated on Drawings.

J. Disinfecting of Domestic Water Systems:
   1. Prior to starting, verify system is complete, flushed and clean.
   2. Verify pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
   3. Inject disinfectant, free chlorine in liquid, powder and tablet or gas form, throughout system to obtain residual from 50 to 80 mg/L.
   4. Bleed water from outlets to obtain distribution and test for disinfectant residual at minimum 15 percent of outlets.
   5. Maintain disinfectant in system for 24 hours.

6. When final disinfectant residual tests less than 25 mg/L, repeat treatment.
7. Flush disinfectant from system until residual concentration is equal to incoming water or 1.0 mg/L.
8. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

K. Install Work in accordance with the 2015 Michigan Plumbing Code.

3.8 INSTALLATION - PLUMBING DRAINAGE PIPING

A. Install bell and spigot pipe with bell end upstream.

B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Install with clearance at cleanout for rodding of drainage system.

C. Encase exterior cleanouts in concrete flush with grade.

D. Install floor cleanouts at elevation to accommodate finished floor.

E. Establish elevations of buried piping outside building to provide not less than 4 ft of cover.

F. Install piping penetrating roofed areas to maintain integrity of roof assembly.

G. Excavate and backfill in accordance with Section 31 20 00.

H. Establish invert elevations, slopes for drainage to 1/4 inch per foot minimum. Maintain gradients.

I. Test drainage piping in accordance with local code requirements.

J. Install Work in accordance with the 2015 Michigan Plumbing Code.

3.9 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Install hangers with minimum 1/2 inch (13 mm) space between finished covering and adjacent work.

C. Place hangers within 12 inches (300 mm) of each horizontal elbow.

D. Use hangers with 1-1/2 inch (38 mm) minimum vertical adjustment.

E. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

F. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.

G. Support riser piping independently of connected horizontal piping.

H. Provide copper plated hangers and supports for copper piping.

I. Design hangers for pipe movement without disengagement of supported pipe.

J. Prime coat exposed steel hangers and supports. Refer to Section 09 90 00. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.10 INSTALLATION - PUMPS

A. Install line size shut-off valve and strainer on pump suction. Install line size check valve, shut-off valve, and balancing valve on pump discharge.

3.11 SERVICE CONNECTIONS

A. Install sanitary, storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and verify proper slope for drainage and proper cover to avoid freezing.

3.12 SCHEDULES

A. Pipe Hanger Spacing:

PIPE MATERIAL	MAXIMUM HANGER SPACING Feet (m)	HANGER ROD DIAMETER Inches (mm)
Cast Iron (All Sizes)	5 (1.5)	5/8 (15)
Cast Iron (All Sizes) with 10 foot (3 m) length of pipe	10 (3)	5/8 (15)
CPVC, 1 inch (25 mm) and smaller	3 (0.9)	1/2 (13)
CPVC, 1-1/4 inches (32 mm) and larger	4 (1.2)	1/2 (13)
Copper Tube, 1-1/4 inches (32 mm) and smaller	6 (1.8)	1/2 (13)
Copper Tube, 1-1/2 inches (38 mm) and larger	10 (3)	1/2 (13)
PVC (All Sizes)	4 (1.2)	3/8 (9)
Steel, 3 inches (75 mm) and smaller	12 (3.7)	1/2 (13)
Steel, 4 inches (100 mm) and larger	12 (3.7)	5/8 (15)

END OF SECTION

SECTION 22 30 00

PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Domestic Water heaters (DWH-1 & DWH-2).

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's literature for plumbing equipment.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit literature and parts list.

1.4 QUALITY ASSURANCE

A. Water Heater Performance Requirements: Equipment efficiency not less than prescribed by ASHRAE 90.1 when tested in accordance with DOE 10 CFR.

B. Perform Work in accordance with the 2015 Michigan Plumbing Code.

PART 2 PRODUCTS

2.1 COMERCIAL GAS WATER HEATERS

A. Manufacturers:
   1. A.O.Smith: Model Nos. BTH-199A (DWH-1) & BTH-300A (DWH-1)
   2. Bradford White
   3. Substitutions: Permitted.

B. Furnish materials in accordance with the 2015 Michigan Plumbing Code.

C. Automatic, natural gas fired, vertical storage type:
   1. Storage capacity, Input & Recovery rate: See Water Heater Schedule on Drawing.

D. Tanks: Welded steel ASME labeled pressure vessel; glass lined, with ASME rated temperature and pressure relief valve.

E. Controls: Automatic immersion water thermostat with adjustable temperature range, automatic reset high limit thermostat, gas pressure regulator, burner with 100 percent safety shut-off pilot and thermocouple, intermittent electronic ignition and automatic flue damper and power vent.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install Work in accordance with the 2015 Michigan Building Code.

B. Install water heaters in accordance to AGA, and UL requirements. Coordinate with plumbing piping and related fuel piping, gas venting and electrical work to achieve operating system.

C. Clean and flush tanks after installation. Keep openings sealed until pipe connections are made.

END OF SECTION

SECTION 224200

COMMERCIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other sections of these specifications, apply to this Section.

1.2 SUMMARY

A. This Section includes plumbing fixtures and related components.

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

1.4 SUBMITTALS

A. Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For plumbing fixtures to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with the 2015 Michigan Plumbing Code.

B. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

C. 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.

D. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities, Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act" about plumbing fixtures for people with disabilities.

E. Regulatory Requirements: Comply with requirements in U.S. Architectural & Transportation Barriers Compliance Board's "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" about plumbing fixtures for people with disabilities.

F. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

G. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

H. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

I. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Hand Sinks: NSF 2 construction.
   2. Stainless-Steel Fixtures Other Than Service Sinks: ASME A112.19.3M.
   3. Vitreous-China Fixtures: ASME A112.19.2M.
   4. Water-Closet, Flushometer Trim: ASSE 1037.

J. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   2. Faucet Hose: ASTM D 3901.
   3. Faucets: ASME A112.18.1M.
   4. Hose-Connection Vacuum Breakers: ASSE 1011.
   5. Hose-Coupling Threads: ASME B1.20.7.
   6. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   7. NSF Materials: NSF 61.
   8. Pipe Threads: ASME B1.20.1.
   9. Supply and Drain Fittings: ASME A112.18.1M.

K. Comply with the following applicable standards and other requirements specified for shower faucets:
   1. Combination, Pressure-Equalizing and Thermostatic-Control Anti-scald Faucets: ASSE 1016.
   2. Thermostatic-Control Anti-scald Faucets: ASTM F 444 and ASSE 1016.

L. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1M.
   3. Manual-Operation Flushometers: ASSE 1037.
   4. Plastic Tubular Fittings and Piping: ASTM F 409.
   5. Tubular Brass Drainage Fittings and Piping: ASME A112.18.1M.

M. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Floor Drains: ASME A112.21.1M.
   2. Hose-Coupling Threads: ASME B1.20.7.
   3. Off-Floor Fixture Supports: ASME A112.6.1M.
   4. Pipe Threads: ASME B1.20.1.
   5. Plastic Toilet Seats: ANSI Z124.5.
   6. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. For fixture descriptions in other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection subject to compliance with requirements; provide products by the manufacturers specified.
   1. Where there is a model number shown, the design is based on that manufacturer and model.

2.2 WATER CLOSET: WC-1, Handicapped accessible, Floor mounted, Tank Type.

A. Bowl shall be floor mounted, vitreous china closet with elongated rim, china bolt caps; manufactured by American Standard Champion Pro 2-piece Model 211AA.104. The water closet shall be rated at 1.28 gallons per flush.

B. Acceptable Manufacturers
   1. American Standard Champion Pro 2-piece Model 211AA.104.
   2. Kohler
   3. Eljer

C. Seat shall be solid white plastic, open front, extended back, self-sustaining hinge, brass bolts, without cover; manufactured by American Standard Model 5359C.051H.

D. Support shall be matching adjustable face plate type with floor support.

2.3 WATER CLOSET: WC-2, Floor mounted, Tank Type.

A. Bowl shall be floor mounted, vitreous china closet with elongated rim, china bolt caps; manufactured by American Standard Champion Pro 2-piece Model 211CA.004. The water closet shall be rated at 1.6 gallons per flush.

B. Acceptable Manufacturers
   1. American Standard Madera model
   2. Kohler
   3. Eljer

C. Seat shall be solid white plastic, open front, extended back, self-sustaining hinge, brass bolts, without cover; manufactured by American Standard Model 5359C.051H.

D. Support shall be matching adjustable face plate type with floor support.

2.4 URINAL: UR-1

A. Urinal shall be wall mounted vitreous china with washout flushing action and integral flush spreader with concealed carrier.

B. Acceptable Manufacturers:
   1. American Standard Washbrook Model 6590.001
   2. Kohler
   3. Eljer

C. Top spud flush valve shall be Sloan Royal 186-1 Flush Valve. The urinal and flush valve shall be rated at 1.0 gallons per flush.

D. Support shall be matching adjustable with bottom bearing plate.

2.5 LAVATORY: L-1.

A. Wall hanging lavatory, vitreous china counter top lavatory 21" x 18" minimum, with 4” center drilling on center.

B. Acceptable Manufacturers:
1. American Standard Lucerne Model 0355.012
2. Kohler
3. Eljer

C. Trim shall be one chrome plated supply fitting, water economy aerator, chrome plated brass P-trap with clean-out plug and arm with escutcheon; manufactured by American Standard 7385050.002.

D. Accessories
1. Lavatory Insulation Kit
   a. Provide the following: Safety covers consisting of molded closed-cell vinyl construction 1/8" thick nominal, white color for tail piece, valves, p-trap and supply piping. Furnish with weep hole and angle valve access covers. Manufacturer: Truebro Lav-Guard.
2. Lavatories designated as barrier-free shape shall be supplied with under counter thermostatic blending valve.

2.6 SINK: S-1

A. Counter-mounting, stainless-steel fixture.
1. Products:
   a. Dayton Products, Inc.
   b. Elkay Manufacturing Co. **Model BLR150C**
   c. Just Manufacturing Co.,
   d. Kohler Co.
   e. Moen, Inc.
   f. Sterling Plumbing Group, Inc.
2. Overall Size: 15" x 15" x 7 1/8”, 18 gauge 304 stainless steel.
3. Number of Compartments: One.
4. Faucet: Elkay **Model LKD2223C**
5. Drain: Type 304 stainless steel cup strainer with removable stainless steel basket with locking shell. Basket fitted with rubber stopper on bottom.
6. Drain Piping: NPS $1^1/_2$ (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.7 SINK: S-2

A. Counter-mounting, stainless-steel fixture.
1. Products:
   a. Dayton Products, Inc.
   b. Elkay Manufacturing Co. **Model LR1720C**
   c. Just Manufacturing Co.,
   d. Kohler Co.

e. Moen, Inc.
f. Sterling Plumbing Group, Inc.

2. Overall Size: 17" x 20" x 7 5/8", 18 gauge 304 stainless steel.
3. Number of Compartments: One.
4. Faucet: Elkay **Model LK406GN04T4C**
5. Drain: Type 304 stainless steel cup strainer with removable stainless steel basket with locking shell. Basket fitted with rubber stopper on bottom.
6. Drain Piping: NPS 1 1/2 (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.8 SINK: S-3

A. Double Bowl Drop-in, stainless-steel sink.

1. Products:
   a. Dayton Products, Inc.
   b. Elkay Manufacturing Co. **Model LR3322PD**
   c. Just Manufacturing Co.,
   d. Kohler Co.
   e. Moen, Inc.
   f. Sterling Plumbing Group, Inc.
2. Overall Size: 33" x 22" x 8 1/8", 18 gauge 304 stainless steel.
3. Number of Compartments: Two.
4. Faucet: Delta **Model 2100 LF**
5. Drain: Type 304 stainless steel cup strainer with removable stainless steel basket with locking shell. Basket fitted with rubber stopper on bottom.
6. Drain Piping: NPS 1 1/2 (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.9 SINK: S-4 (Single Compartment Scullery Sink)

A. Single Compartment Scullery Sink.

1. Products:
   a. Dayton Products, Inc.
   b. Elkay Manufacturing Co. **Model WNSF81362**
   c. Just Manufacturing Co.,
   d. Kohler Co.
   e. Moen, Inc.
   f. Sterling Plumbing Group, Inc.
2. Overall Size: 39" x 27 1/2" x 14", 14 gauge, floor mount 304 stainless steel.
3. Number of Compartments: One.
4. Faucet / Strainer: Elkay **Model LK940VS07T4S / LKPDVR18B**
5. Drain Piping: NPS 1 1/2 (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.10 SINK: S-5A (Cat Wash Station)

A. Cat Wash Station.

1. Products:

a. Mfr. Vecor. **Model VV-PET34SSZKM**

2. Overall Size: 34.2” (L) x 18.4” (W) x 43.3” (H), 201 stainless steel.
3. Adjustable Sprayer & Faucet: The pet washing station comes with a high-pressure sprayer (3 types of water outlet volume) and a faucet with two hoses (adjust water temperature) to give pets a warm and comfortable bath. Besides, there is a non-skid floor grate for detachable to fit different pet sizes and keep pet away from long-term soaking in the water.
4. Drain Piping: A drain strainer for filtering pet fur and other dirt. NPS $1^1/_2$ (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.11 SINK: S-5B (Dog Wash Station)

A. Dog Wash Station.

1. Products:
   a. Mfr. Vecor. **Model VV-CWZG201BXG-62IN**
2. Overall Size: 59.2” (L) x 27.7” (W) x 57.9” (H), 304 stainless steel.
3. Adjustable Sprayer & Faucet: The pet washing station comes with a high-pressure sprayer (3 types of water outlet volume) and a faucet with two hoses (adjust water temperature) to give pets a warm and comfortable bath. Besides, there is a non-skid floor grate for detachable to fit different pet sizes and keep pet away from long-term soaking in the water.
4. Drain Piping: A drain strainer for filtering pet fur and other dirt. NPS $1^1/_2$ (DN 40) chrome-plated cast-brass trap, 0.045" (1.1 mm) thick tubular brass waste to wall, and wall escutcheons.

2.12 SINK: SS-1 (Service Sink – Floor Mounted)

A. Service Sink – Floor Mounted.

1. Products:
   a. Mustee. **Model 63M**
2. Overall Size: 24" x 24" x 10” (H), floor mount, High impact resistant DURASTONE® structural fiberglass.
3. Faucet: Mustee **Model 63.600A**

2.13 SHOWER: SH-1

A. Shower valve and head system.

B. Acceptable Manufacturers:

1. Symmons Temptrol, **Model C-96-1-x**
2. American Standard
3. Kohler
4. Chicago

C. Trim: Chrome plated brass

2.14 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Guard: Manufactured, plastic covering for hot and cold-water supplies and trap and drain piping and complying with ADA requirements.

1. Manufacturers:

a. TruBro
b. Zurn
c. Similar as approved

2.15 FIXTURE SUPPORTS

A. Urinal Support: Urinal carrier with fixture support plates and coupling with seal and fixture bolts, hardware matching fixture and bearing plates. Include steel uprights with feet.
1. Manufacturers:
a. Josam
b. Mifab
c. Smith
d. Wade
e. Zurn, 1222 Series

2.16 FOOD WASTE DISPOSER

A. Batch feed, household, food-waste disposer. Include 115-V ac, 1725 rpm, 3/4 hp motor with overload protection and reset button; 3 conductor, grounded power cord; wall switch; corrosion-resistant chamber with jam-resistant, cutlery or stainless steel grinder or shredder; NPS $1^1/_2$ (DN 40) outlet; quick-mounting, stainless steel sink flange; anti-splash guard, combination cover/stopper. The unit shall be equipped with a sound-insulated chamber and stainless-steel outer shell. Mount in S-3.
1. Manufacturers:
a. Insinkerator **Badger 5XP**
b. Kitchen Aid
c. Viking

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water, soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.

B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.

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

3.2 FIXTURE INSTALLATION

A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. For wall-hanging fixtures, install off-floor supports affixed to building substrate.
1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-hanging fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-hanging fixtures with tubular waste piping attached to supports.

F. Install counter-mounting fixtures in and attached to casework.

G. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.

H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

I. Exception: Use ball valves if stops are not specified with fixture.

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install toilet seats on water closets.

M. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

N. Install water-supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.

O. Install faucet, flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

Q. Install escutcheons at piping wall, ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings.

R. Set service basins in leveling bed of cement grout.

S. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect water supplies from water distribution piping to fixtures.

C. Connect drain piping from fixtures to drainage piping.

D. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use size fittings to match fixtures. Connect to plumbing piping.

E. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping specified. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

F. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Verify that installed fixtures are categories and types specified for locations where installed.

B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers and controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets, shower valves, and Flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 230500

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Provide labor, materials, equipment, supervision, and incidental services as necessary to complete all BASIC MECHANICAL MATERIALS AND METHODS work as indicated on the Drawings and as specified herein, including, but not limited to:

1. Connection of/to utilization equipment.
2. Grout.
3. Mechanical demolition.
4. Equipment installation requirements common to equipment sections.
5. Painting and finishing.
6. Supporting devices for electrical components.
7. Concrete equipment bases.
8. Supports and anchorages.
9. Cutting and patching for mechanical construction.

B. Demolition: As indicated on the drawings.

C. Substitutions:

1. The Contractor’s base bid must be in accordance with the materials or products specified. Any exceptions to this must me approved in writing by the Engineer, ten (10) days or more prior to bidding.

1.3 QUALITY ASSURANCE

A. The following items shall be performed for quality assurance:

1. Perform Work to requirements of the acceptable standards of installation.
2. Use personnel with appropriate experience to perform Work on all systems.
3. Verify that field measurements are as shown on Drawings.
4. Report all discrepancies to Engineer.
5. Conform to all applicable Codes and Standards.

B. Permits and Inspections:

1. The Contractor shall obtain and pay for all required permits (temporary and permanent), fees, inspections and Certificates of Inspection for the work specified herein as required by any and all applicable laws and/or ordinances. The cost of such permits and certificates shall be included in the Contractor's bid price, unless otherwise directed. Post such permits and Inspection Certificates in a prominent place adjacent to the work.
2. Deliver all certificates of final inspection or approval to the office of the Design Professional.

3. Do not cover any concealed work until final inspection has been made and approval certificates obtained.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic and rubber materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.
5. EPDM: Ethylene-propylene-diene terpolymer rubber.
6. NBR: Acrylonitrile-butadiene rubber.

1.5 SUBMITTALS

A. Submit sufficient copies required to insure that the Owner has one (1) copy and the Design Professional has one (1) copy.

B. Submit shop drawings and product data grouped to include complete submittals of related systems, products and accessories in a single submittal. Tabulated type product data sheets are to be clearly marked to indicate specific items.

C. ALL shop drawings and product data shall be transmitted to the Design Professional within fifteen (15) working days of the Notice to Proceed.

D. The initial Construction Progress Schedule shall be transmitted to the Design Professional in duplicate within ten (10) working days after the date established in the Notice to Proceed for the Design Professional’s review.

E. Submit shop and installation drawings, which shall serve the purpose of checking the Contractor's interpretation of the design drawings and specifications, and in correlation and coordination of the various trades, and be used by the Contractor's field workers as installation instructions. They shall include a complete schedule of materials, ductwork and equipment, which he/she intends to install for approval by the Engineer, as soon as practicable after the contract award, but in any event, prior to installing any materials or equipment. Provide operations and maintenance materials, which shall include schematic diagrams.

F. Review submittals and coordinate with equipment furnished under other Sections prior to installation and rough-in. Verify location, size, and type of connections. Coordinate details of equipment connections with supplier and installer.

G. In general, where specified trade names are mentioned, they are intended to indicate quality, appearance and type of construction required and not to restrict competition. The Engineer's decisions as to acceptability of substitute materials will be final and shall be binding on the Contractor.

H. All manufacturer's drawings, catalog cuts and specifications shall be properly identified with the Engineer's Job Title and Job Number. Each piece of equipment shall be properly identified as to its location and equipment number. Mark dimensions and values in units to match those specified.

I. Prepare and furnish to the Engineer three (3) bound copies “Operating and Maintenance Manual" on all equipment installed under this Contract.

J. Welding certificates.

K. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

L. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

M. Operating and Maintenance Manuals.

1. When the project is substantially complete and before the project is taken over by the Owner for maintenance purposes, the Contractor shall be required to provide the Design Professional with three (3) complete sets of written instructions covering the proper operation and maintenance requirements of all equipment furnished under these specifications.
2. The manual shall consist of an indexed loose-leaf binder containing the manufacturer's installation, operating, maintenance, lubrication and repair parts manual for each system component; approved shop drawings including equipment performance data and pump and fan performance curves; test and balance reports; and drawings showing rooms or areas served by each of the various heating, ventilating and air conditioning systems. Small scale drawings will be furnished by the Owner’s Engineer / Architect for this purpose if desired. Should clarification be required on any of the above requirements, sample copies of acceptable manuals are available for inspection. All outsize sheets shall be recopied to provide uniformity of size.

1.6 DELIVERY, STORAGE, AND HANDLING

A. As indicated in each of the specification sections.

1.7 COORDINATION

A. The accompanying Drawings show the arrangement, general design and extent of the work and are more or less diagrammatical with equipment in its general location, except that in certain cases the drawings may include details giving exact location and arrangement.

B. The Drawings are not intended to be scaled for roughing-in or to serve as shop drawings. If drawings are required for this purpose, or have to be made from field measurements, it shall be the responsibility of the Contractor to prepare such drawings.

C. The Plans and Specifications are intended to include all work and materials for the entire completion of the work. Any item of material, labor or detail required for proper execution and completion of the work and omitted from either the plans and specifications or both, but obviously understood and or required to make all systems complete and operable, shall be furnished as part of the contract without additional cost even though not specified or shown.

D. Before any work is installed, and before any equipment is fabricated or purchased, the Contractor shall consult all contract documents in addition to the Mechanical Drawings, including Architectural, Structural, Civil/Site, Electrical and others, insofar as they may affect his work or affect the location of equipment, piping or duct work; and shall be held to be thoroughly conversant with the construction problems insofar as they affect his work and to coordinate with the other trades in doing their work and locating equipment.

E. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

F. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

G. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

1.8 CONFLICT BETWEEN DRAWINGS AND THESE SPECIFICATIONS

A. The drawings and these specifications are to be treated as mutually equal. ONE DOES NOT TAKE PRECEDENCE OVER THE OTHER.

B. Where there is a conflict between the drawings and the specifications, the contractor SHALL contact the Engineer for clarification.

C. In the event the Engineer is not available to respond to the conflict, the contractor SHALL ASSUME THAT THE HIGHER QUALITY ITEM SHALL BE BID.

1.9 EXAMINATION AND ACCEPTANCE OF WORK IN PLACE

A. Examine work in place on which specified work is dependent. Defects which may influence satisfactory completion and performance of specified work shall be corrected in accordance with the requirements of the applicable section of work prior to the commencement of the specified work. Commencement shall be construed as work in place being acceptable for satisfying the requirements of this section.

1.10 OMISSIONS

A. The intent of these Specifications and Drawings is to secure a complete and operating job in all regards. If any major or obvious omissions exist, the Contractor shall question such items prior to submitting his/her bid; furthermore, the omission from the Drawings and Specifications of any minor detail of construction or installation, shall not relieve the Contractor from providing and installing same. Such omissions shall not entitle the Contractor to make claim for extras for materials or labor.

1.11 STRUCTURAL DIFFICULTIES

A. Should any field conditions prevent the locating of any mechanical equipment as shown on the plans, the Contractor is required to make any minor deviations, as determined by the Engineer, without extra cost.

1.12 FIELD MEASUREMENTS

A. Take field measurements to verify or supplement dimensions indicated.

B. All measurements necessary for the proper installation of the work shall be taken in the field.

1.13 LAWS, REGULATIONS, CODES AND STANDARDS

A. All work and materials shall be in conformity with all applicable Federal, State and Local Laws, codes and regulations, as well as, applicable current standards.

B. Where the requirements of the Contract Documents exceed those of the laws, regulations and standards mentioned above, the requirements of the Contract Documents shall govern.

C. All equipment and materials shall be listed by Underwriters Laboratories, Inc., except for classes of equipment not available with such listings.

D. Obtain permits and inspections from the authority (ies) having jurisdiction.

1.14 REFERENCE STANDARDS

A. The work shall comply with the requirements of the latest edition of the following standard specifications, as applicable.

1. MBC: Michigan Building Code
2. MPC: Michigan Plumbing Code
3. MMC: Michigan Mechanical Code
4. OSHA: Occupational Safety & Health Administration.
5. ASHRAE: Standard for the design, fabrication and installation of HVAC systems.
6. SMACNA: Standard for the design, fabrication and installation of duct work.
7. NFPA: National Fire Protection Association.
8. ASME: American Society of Mechanical Engineers.
9. ASTM: American Society for Testing Materials.
10. ANSI: American National Standards Institute.
11. UL: Underwriters Laboratories

1.15 CURRENT CHARACTERISTICS

A. All motors 1/2 HP and greater shall be 3 phase, 208V or 460V, 60HZ, unless otherwise noted.

B. All motors less than 1/2 horsepower shall be single phase, 120V, 60HZ, unless otherwise noted.

1.16 ELECTRICAL CHARACTERISTICS

A. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

B. The mechanical contractor shall supply all starters, safety switches and other motor control equipment necessary to properly operate and control all controls for mechanical equipment shall be installed by the electrical contractor.

1.17 MAINTENANCE

A. Contractor shall be responsible for maintenance of equipment and systems installed until final acceptance by Owner.

1.18 WARRANTIES

A. In the event that any part of the work or equipment fails (abuse and causes beyond control of the Contractor excepted), within this period of guarantee, it shall be replaced by the Contractor at no cost to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, subject to compliance with requirements, provide products by the manufacturers specified.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 INSTALLATION

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

B. Character of Work: The installation shall be executed in a workmanlike manner and shall present a neat mechanical appearance when completed.

C. Laying Out Work

1. Layout equipment in accordance with the contract documents and the manufacturers recommended practice including provision of adequate space for maintenance. Review layout with the Design Professional prior to installation.
2. Check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, notify the Design Professional before proceeding with installation.
3. If directed by the Design Professional, the contractor shall make reasonable modifications in the layout as required to permit proper execution of the work and to prevent conflict with work of other trades.
4. Work shall be installed so as to be readily for operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this. Changes shall not be made without approval of the Construction Representative.

D. Connection to Existing Systems

1. Connections to existing system shall be arranged in advance and shall be made at the convenience of the Owner.
2. Existing water systems that must be drained for contract work must be refilled and purged of air at the job end. The contractor shall replace any water treatment that was removed during the system draining. The Owner shall be consulted as to the type and quantity of water treatment.

E. Accessibility

1. Access doors/panels shall be provided in all pipe chases, soffits, walls and ceilings.
2. Coordinate the exact location with the work of other trades.
3. Verify the exact quantity, size and location of the required access panels/doors after the installation of systems and equipment requiring access, and prior to the closure of the affected ceilings and building assemblies.

3.3 STRUCTURAL DIFFICULTIES

A. Should any field conditions prevent the locating of any equipment as shown on the plans, the Contractor is required to make any minor deviations, as determined by the Engineer, without extra cost.

3.4 FIELD MEASUREMENTS

A. Take field measurements to verify or supplement dimensions indicated.

B. All measurements necessary for the proper installation of the work shall be taken in the field.

3.5 FIELD QUALITY CONTROL

A. Site Tests

1. Furnish all labors and equipment necessary for the completion of all tests called for in these specifications.
2. Arrange with all authorities to complete the tests without unnecessary delays so that the work may progress as rapidly as possible. Notify the Construction Representative in advance of all tests, at least 24 hours before starting any tests.
3. Tests shall be repeated after any defects disclosed thereby have been made good or the work replaced, if in the judgment of the Construction Representative, it is deemed necessary.
4. Test Equipment: Instrumentation shall be provided as necessary and appropriate to perform the work. The instrument shall be factory calibrated, and shall be used with the factory-determined application factors. When reasonable doubt of accuracy exists, recalibration of any or all instrumentation shall be performed as requested by the Architect /Engineer.

3.6 CUTTING AND PATCHING

A. No cutting or patching shall be done which is liable to impair the strength of the building, without the approval of the Engineer.

B. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

C. All openings made by the Contractor shall be neatly patched by him after the work is done. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing fire-stopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.7 PLUMBING EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.8 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in other sections of these specifications.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.9 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4" (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18" (450 mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000 psi (20.7 MPa), 28 day compressive strength concrete and reinforcement.

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.12 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.13 OPERATING TESTS

A. Following the complete installation of all materials and equipment covered by these Specifications, the Contractor shall conduct operating tests on the various systems installed to demonstrate that all equipment is in proper operating condition, correctly adjusted and calibrated for satisfactory functional and operating efficiency, as outlined hereinafter.

3.14 ACCEPTANCE OF INSTALLATION

A. The Engineer may accept an equipment system installation as substantially complete when:
   1. All components of a system are installed.
   2. All factory test(s) have been approved by the Engineer.
   3. All performance shop test(s) have been approved by the Engineer.
   4. Field start-up activities have been completed and approved by the Engineer.
   5. The required equipment has met the performance requirements.
   6. All required Owner's personnel have been trained.
   7. The certificate from the manufacturer stating that the installation of the equipment is satisfactory, that the unit has been satisfactorily tested, is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication, and care of the unit have been submitted.
   8. The O & M Manuals have been approved by the Engineer.

3.15 GUARANTEE

A. The Contractor shall provide a written guarantee to the Owner on the work and equipment which shall be good for one (1) year or longer as may be specified hereinafter.

END OF SECTION

SECTION 230501

MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.
2. Nameplate legends.
3. Diagrams of power and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.

B. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.

C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated.

D. 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.

E. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Engineer at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
2. Indicate method of providing temporary utilities.
3. Do not proceed with utility interruptions without Engineer's written permission.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:
   a. Magnetic controllers.
   b. Multispeed controllers.
   c. Reduced-voltage controllers.
2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in other sections of these specifications.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor starters shall be provided by the mechanical contractor. Where the starters are not mounted on the equipment, they shall be installed by the Electrical Contractor.

B. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for motor(s) may be specified in other Section(s) of these specifications.
2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR STARTERS

A. Manual Motor Starter:

1. NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller with overload relay, red pilot light, auxiliary contact, and push button operator.

2. Fractional horsepower manual starter shall meet NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, red pilot light, and toggle operator.
3. Enclosure shall meet NEMA ICS 6; Type 1.

B. Magnetic motor starter shall meet NEMA ICS 2.
1. Full voltage motor starters shall be AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

C. Furnish properly tagged starters for all motors.

D. Furnish and install all heater elements for overload protective devices. Elements shall be sized and selected on the basis of being nameplate rating on the motors of the pieces of equipment being installed.

E. Mount all motor starters and wire all final connections between the starters and motors.

F. All starters shall be furnished with an "ON-OFF-AUTO" switch and indicating lights mounted in the cover of the starter.

2.3 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and larger: Three phase, unless otherwise noted.

B. Motors smaller than 1/2 HP: Single phase, unless otherwise noted.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105^0F (40^0C) and at altitude of 3,300 feet (1005 m) above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open drip proof.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Standard efficiency according to NEMA MG 1, Para. 12.59 and Table 12-10.

C. Stator: Copper windings, unless otherwise indicated.
1. Multi0speed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or G.
   2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
   1. Finish: Gray enamel.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Designed with critical vibration frequencies outside operating range of controller output.
   2. Temperature Rise: Matched to rating for Class B insulation.
   3. Insulation: Class H.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.
   1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
   1. Measure winding resistance.
   2. Read no-load current and speed at rated voltage and frequency.
   3. Measure locked rotor current at rated frequency.
   4. Perform high-potential test.

2.6 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split-phase start, capacitor run.
   3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

E. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
   1. Measure winding resistance.

2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

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

3.2 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with other sections of these specifications.

C. Comply with mounting and anchoring requirements specified in other sections of these specifications.

3.3 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
   2. Test interlocks and control features for proper operation.
   3. Verify that current in each phase is within nameplate rating.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Verify bearing lubrication.
   4. Verify proper motor rotation.
   5. Test Reports: Prepare a written report to record the following:
      a. Test procedures used.
      b. Test results that comply with requirements.
      c. Test results that do not comply with requirements and corrective action taken to achieve compliance.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

SECTION 230523

VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Provide labor, materials, equipment, supervision and incidental services as necessary to complete all VALVE work as indicated on the Drawings and as specified herein.

1.3 QUALITY ASSURANCE

A. All valves shall be installed with the stems in the upright position.

B. Install valves in accordance with the manufacturer's recommendations.

1.4 SUBMITTALS

A. All submittals shall conform to previous sections of these specifications. Tabulated type product data sheets are to be clearly marked to indicate specific items.

PART 2 - PRODUCTS

2.1 VALVES - GENERAL

A. Acceptable manufacturers for all valves listed herein:
1. Crane Company
2. Jenkins
3. Nibco.
4. Milwaukee Valve Co
5. Zurn
6. Kennedy
7. Stockham
8. William Powell Co.
9. Red and White

2.2 BALL VALVES

A. Up to 2" shall be bronze or stainless steel body, stainless steel ball, Teflon seats and stuffing box ring, lever handle, solder or threaded ends.

B. Over 2" shall be cast steel body, chrome plated steel ball, Teflon seat and stuffing box seals, lever handle, flanged.

2.3 BUTTERFLY VALVES

A. Iron body, bronze disc, resilient, replaceable seat for service to 180^0F, wafer or lug ends, 10 position lever handle.

2.4 SWING CHECK VALVES

A. Up to 2" shall be bronze swing disc, solder or screwed ends.

B. Over 2" shall be iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

2.5 RELIEF VALVES

A. Bronze body, Teflon seat, steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves with stems upright (preferred), 45^0 (next) or horizontal (least). Valves installed in the inverted position are not allowed.

B. Provide access to valves where valves are not exposed. Coordinate size and location of access doors with plans and other sections of these specifications.

C. Provide clearance for installation of insulation and access to valves and fittings.

D. Install ball or butterfly valves for shut-off and to isolate equipment, parts of systems or vertical risers.

E. Install ball or butterfly valves for throttling, bypass or manual flow control services.

F. Provide spring loaded check valves on discharge of water pumps

G. Tag all valves.

H. Provide one plug cock wrench for every ten plug cocks sized 2" and smaller, minimum of one. Provide each plug cock sized $2^1/_2$" and larger with a wrench with set screw.

I. Provide spring loaded check valves on discharge of water pumps.

END OF SECTION

SECTION 230529
HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:
    a. AAA Technology and Specialties Co., Inc.
    b. B-Line Systems, Inc.
    c. Carpenter & Patterson, Inc.
    d. Empire Tool & Manufacturing Co., Inc.
    e. Globe Pipe Hanger Products, Inc.
    f. Grinnell Corp.
    g. GS Metals Corp.
    h. Michigan Hanger Co., Inc.
    i. National Pipe Hanger Corp.
    j. PHD Manufacturing, Inc.
    k. PHS Industries, Inc.
    l. Piping Technology & Products, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
2. Non-metallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

2.3 MISCELLANEOUS MATERIALS

A. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

C. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and non-metallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN15 to DN750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN100 to DN400), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN15 to DN600), if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN15 to DN100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN20 to DN200).

7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN15 to DN50).
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN10 to DN200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN10 to DN80).
12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30 (DN15 to DN750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN65 to DN900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN25 to DN750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN65 to DN500), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN50 to DN1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN50 to DN600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
   2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
   3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
   4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
   5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
   10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
   11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
   12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
      a. Light (MSS Type 31): 750 lb (340 kg).
      b. Medium (MSS Type 32): 1500 lb (675 kg).
      c. Heavy (MSS Type 33): 3000 lb (1350 kg).
   13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
   14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
   15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

G. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

C. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

D. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

E. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

G. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.9.
   2. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.
   3. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
      b. NPS 4 (DN100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
      c. NPS 5 and NPS 6 (DN125 and DN150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
      d. NPS 8 to NPS 14 (DN200 to DN350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
      e. NPS 16 to NPS 24 (DN400 to DN600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
   4. Pipes NPS 8 (DN200) and Larger: Include wood inserts.
   5. Insert Material: Length at least as long as protective shield.
   6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 230548

MECHANICAL VIBRATION AND SEISMIC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Vibration isolators
   2. Vibration isolation equipment bases

1.3 PERFORMANCE REQUIREMENTS

A. All mechanical vibration and seismic controls must meet applicable codes.

1.4 SUBMITTALS

A. Product Data: Include load deflection curves for each vibration isolation device.

B. Shop Drawings: Include the following:
   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 VIBRATION ISOLATORS

A. Manufacturers:

1. Ace Mounting Co., Inc.
2. Amber/Booth Company, Inc.
3. B-Line Systems, Inc.
4. California Dynamics Corp.
5. Isolation Technology, Inc.
6. Kinetics Noise Control, Inc.
7. Mason Industries, Inc.
8. Vibration Eliminator Co., Inc.
9. Vibration Isolation Co., Inc.
10. Vibration Mountings & Controls/Korfund.

B. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a non-slip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene or Natural rubber.
2. Durometer Rating: 40.
3. Number of Layers: 2.

C. Elastomeric Mounts Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Durometer Rating: 40.

D. Restrained Elastomeric Mounts: All-directional elastomeric mountings with seismic restraint.

1. Materials: Cast-ductile-iron housing containing two separate and opposing, molded, bridge-bearing neoprene elements that prevent central threaded sleeve and attachment bolt from contacting the casting during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4" (6 mm) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig (690 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4" (6 mm) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4" (6 mm) travel before contacting a resilient collar.

H. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30^0 of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

I. Spring Hangers with Vertical-Limit Stop Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degree of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

J. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2" (13 mm) thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

K. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of 1/2" (13 mm) thick, 60 durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers:
1. Amber/Booth Company, Inc.
2. California Dynamics Corp.
3. Isolation Technology, Inc.
4. Kinetics Noise Control, Inc.
5. Mason Industries, Inc.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation Co., Inc.
8. Vibration Mountings & Controls/Korfund.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than 1" (25 mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for field-applied, cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1" (25 mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1. Powder coating on springs and housings.
2. All hardware shall be electrogalvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 INSTALLATION

A. Install roof curbs, equipment supports, and roof penetrations as specified in other sections of these specifications.

B. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

C. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

D. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.

E. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

F. Install resilient bolt isolation washers on equipment anchor bolts.

3.3 EQUIPMENT BASES

A. Fill concrete inertia bases, after installing base frame, with 3000 psi (20.7 MPa) concrete; trowel to a smooth finish.
   1. Cast-in-place concrete materials and placement requirements are specified in other sections of these specifications.

B. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18" (450 mm) centers around the full perimeter of the base.
   2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   6. Cast-in-place concrete materials and placement requirements are specified in other sections of these specifications.

3.4 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

C. Testing: Perform the following field quality-control testing:
   1. Isolator seismic-restraint clearance.
   2. Isolator deflection.
   3. Snubber minimum clearances.

3.5 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust snubbers according to manufacturer's written recommendations.

E. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

F. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.6 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems.

END OF SECTION

SECTION 230553

MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
   1. Equipment nameplates.
   2. Equipment markers.
   3. Equipment signs.
   4. Access panel and door markers.
   5. Pipe markers.
   6. Duct markers.
   7. Stencils.
   8. Valve tags.
   9. Valve schedules.
   10. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
   1. Data:
      a. Manufacturer, product name, model number, and serial number.

b. Capacity, operating and power characteristics, and essential data.
c. Labels of tested compliances.
2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
1. Terminology: Match schedules as closely as possible.
2. Data:
a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
3. Size: $2^1/_2$ by 4 inches (64 by 100 mm) for control devices, dampers, and valves; $4^1/_2$ by 6 inches (115 by 150 mm) for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine sub-core, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Thickness: 1/16 inch (1.6 mm), unless otherwise indicated.
4. Retain and edit subparagraph above or first subparagraph below.
5. Thickness: 1/16 inch (1.6 mm) for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3.2 mm) for larger units.
6. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

D. Access Panel and Door Markers: 1/16-inch (1.6-mm) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.
1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of $1^1/_4$ inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.
   1. Stencil Material: Metal or fiberboard.
   2. Stencil Paint: Exterior, gloss, alkyd enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4 inch (6.4 mm) letters for piping system abbreviation and 1/2 inch (13-mm) numbers, with numbering scheme approved by Engineer. Provide 5/32 inch (4 mm) hole for fastener.
   1. Material: 0.032-inch- (0.8-mm-) thick brass.
   2. Valve-Tag Fasteners: Brass wire-link chain.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by $5^1/_4$ inches (75 by 133 mm) minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other sections of these specifications. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have a nameplate or has a nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
   2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   3. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   4. Fans, blowers, primary balancing dampers, and mixing boxes.
   5. Packaged HVAC central-station and zone-type units.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
   1. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
      a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
      b. Fire department hose valves and hose stations.
      c. Meters, gages, thermometers, and similar units.
      d. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
      e. Pumps, compressors, chillers, condensers, and similar motor-driven units.
      f. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
      g. Fans, blowers, primary balancing dampers, and mixing boxes.
      h. Packaged HVAC central-station and zone-type units.
      i. Tanks and pressure vessels.
      j. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

D. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
   1. Identify mechanical equipment with equipment markers in the following color codes:

a. Green: For cooling equipment and components.
b. Yellow: For heating equipment and components.
c. Green and Yellow Orange: For combination cooling and heating equipment and components.
d. Brown: For energy-reclamation equipment and components.

2. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
4. Include signs for the following general categories of equipment:
   a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
   b. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
   c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   d. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   e. Fans, blowers, primary balancing dampers, and mixing boxes.
   f. Packaged HVAC central-station and zone-type units.
   g. Tanks and pressure vessels.
   h. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

E. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

F. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Pretensioned pipe markers. Use size to ensure a tight fit.
2. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch (19 mm) wide, lapped at least $1^1/_2$ inches (38 mm) at both ends of pipe marker, and covering full circumference of pipe.
3. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least $1^1/_2$ inches (38 mm) wide, lapped at least 3 inches (75 mm) at both ends of pipe marker, and covering full circumference of pipe.

B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles] [complying with ASME A13.1 on each piping system.
1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts in the following color codes:
   1. Green: For cold air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Blue: For exhaust, outside, relief, return, and mixed air ducts.
   4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
   5. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

B. Stenciled Duct Marker Option: Stenciled markers, showing service and direction of flow, may be provided instead of laminated-plastic duct markers, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

C. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
   1. Valve-Tag Size and Shape:
      a. Cold Water: $1^1/_2$ inches (38 mm) round.
      b. Hot Water: $1^1/_2$ inches (38 mm) round.
      c. Fire Protection: $1^1/_2$ inches (38 mm) round.
      d. Gas: $1^1/_2$ inches (38 mm) round.
      e. Steam: $1^1/_2$ inches (38 mm) round.
   2. Valve-Tag Color: Natural.
   3. Letter Color: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.7 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION

SECTION 230593

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Provide labor, materials, equipment, supervision, and incidental services as necessary to complete all TESTING, ADJUSTING AND BALANCING as indicated on the Drawings and specified herein, including, but not limited to:

1. Testing, adjusting, and balancing of air systems.
2. Testing, adjusting, and balancing of hydronic systems.

1.3 QUALITY ASSURANCE

A. This Specification shall provide for the services of an INDEPENDENT TEST AND BALANCE AGENCY, which specializes in the balancing and testing of heating, ventilating, and air conditioning systems; to provide testing and balancing of air moving equipment and distribution, heating equipment and distribution, all as shown on the accompanying plans and specifications; to provide sound tests. The T&B agency shall be a member of the AABC or NEBBS.

B. Measurement, testing, adjusting and balancing of the systems shall be performed in accordance with ASHRAE Standard 111-1988. Particular attention is directed to Paragraph 8.6.2.3(a) thru (d). Air measurements in both rectangular and circular ducts may be performed using the “Log-Tchebycheff rule”.

C. Upon completion of the HVAC system, the test and balance agency shall perform the tests listed hereinafter, compile the test data, and submit seven (7) copies of the complete test data to the Engineer for evaluation and approval. The Test & Balance Agency shall comply with all standards as set forth by this national organization. All instruments used by this agency shall be accurately calibrated and maintained in good working order. If requested, the tests shall be conducted in the presence of the Engineer and a representative of the Owner.

D. Test & Balance Agency shall visit job site twice during the progress of construction at times designated by the Engineer to assure that all facilities required for his/her performance are provided properly.

E. Test & Balance Agency shall review and comment upon all shop drawings related to his/her work.

F. Air and water balance and testing shall not begin until system has been completed and is in full working order. The Contractor shall put all heating, ventilating, and air conditioning systems and equipment into full operation and shall continue the operation of same during each working of testing and balancing.

G. Test and Balance Agency shall include an extended warranty of 90 days, after completion of Test and Balance work, during which time the Engineer, at his/her discretion, may request a recheck, or resetting of any outlet, supply air fan, or exhaust fan as listed in test report. The Test & Balance Agency shall provide technicians to assist the Engineer in making any tests he/she may require during this period of time. The first thirty (30) days of this warranty period shall be designated as the tuning period. This period shall begin after completion of the Test and Balance work and after occupancy by the Owner.

H. During the thirty (30) day tuning period, the Contractor together with the Test and Balance agency and the Engineer, shall tune the systems, apparatus and controls to suit the Owner's requirements in his/her operations.

I. The tuning period shall commence upon a date to be selected by the Owner's Operating Engineer and the Engineer's Representative and the period shall continue for one (1) calendar month thereafter. The Owner's operating Engineer will receive all complaints regarding the performance of the heating, ventilating, and air conditioning systems; the Contractor and the Engineer shall visit the site and call upon the Owner's Operating Engineer each day of the tuning period. The Test and Balance Agency shall be required to have a representative at the building for an average of two (2) days per week during the tuning period; these days to be determined by the Engineer. The Engineer and the Contractor shall analyze and organize the complaints and promptly affect the correction work necessary. They shall maintain a comprehensive log of the complaints, showing the time, analysis, corrective work and results.

J. The correct function and sequence of controls shall be verified prior to the start of the measurement and testing. Refer to ASHRAE 111 Sections 10 and 11.

K. The system shall be simulated for seasonal conditions. Pressure differential and temperature differential tests shall be made and recorded upon completion of flow tests.

L. If opposite season operating conditions cannot be simulated, testing of systems and equipment shall be scheduled for the earliest convenient date during the opposite season, and a supplemental report of results issued.

1.4 SUBMITTALS

A. All submittals shall conform to previous sections of these specifications. Tabulated type product data sheets are to be clearly marked to indicate specific items.

B. Prior to commencing work, submit draft reports indicating data required. Include detailed procedures, sample report forms, and copy of AABC National Project Performance Guaranty.

C. Submit prior to final acceptance of project and for inclusion in operating and maintenance manuals. Provide in soft cover, letter size, 3-ring binder, with index page and tabs, and cover identification. Include reduced scale drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

D. AABC National Standards for Total System Balance NEBB forms.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Before commencing work, verify that systems are complete and operable.

B. Report any defects of deficiencies or abnormal conditions in mechanical systems which prevent system balance.

C. Beginning of work means acceptance of existing conditions.

D. Recorded data shall represent actually measured or observed condition.

E. Permanently mark settings of valves, dampers, and other adjustment devices. Set and lock memory stops.

3.2 INSTALLATION TOLERANCES

A. Adjust air handling systems to plus or minus 5% for supply systems and plus or minus 5% for return and exhaust systems from figures indicated.

B. Adjust hydronic systems to plus or minus 5% of design conditions indicated.

3.3 LOCATION OF BALANCING DEVICES

A. The location of balancing devices is important in assuring accurate measurements of fluid flow and proper balancing without creating noise in the system.

B. Air balancing dampers shall be of the single or multi-leaf type with a suitable locking quadrant. Splitters are generally not acceptable. Dampers shall be installed in all of the following by the sheet metal contractor:

1. In all branch ducts of the low pressure side of the supply system and in all of the branch ducts of the return and exhaust systems. The dampers shall be located as close to the branch connection to the main as possible.
2. In all take-offs to the terminal devices located as close to the take-off connection to the branch as possible. The integral damper in the terminal devices shall not be used for balancing.

C. Water balancing valves shall be of the plug or butterfly type with a suitable locking device or means of marking position of valve. Balancing valves shall be installed in all of the following locations by the heating contractor:

1. At the return connection of each branch to the main return.
2. At the outlet of each and every coil and terminal device in the system.
3. In the by-pass lines of all three-way valves.

D. Pipe line openings for pressure readings shall be valved with 1/4" flare outlet shut-off valves as follows by the heating contractor:

1. At the pump suction and discharge.
2. At the inlet and outlet of various primary and terminal elements in the system.

E. Flow meter openings for portable flow meters shall be plugged 1/4" short nipple and gate valve located at a distance of no less than 5 pipe diameters downstream. Pipe openings shall be clean with all burrs removed from inside the pipe to obtain as little disturbance to flow as possible. Flow meter openings shall be installed at all of the following locations:
   1. In the main supply or return.
   2. In each branch return of the system.
   3. In the supply or return to each coil and terminal device.

F. In the circuit to each boiler, and converter, wherever more than one (1) of each is used in parallel flow operation.

3.4 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.

B. Make air quantity measurements in ducts by traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers.

E. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

F. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Allow for 50% loading of filters.

G. Adjust automatic outside air, return air, and exhaust air dampers for design conditions.

H. Measure temperature conditions across outside air, return air, and exhaust air dampers to check leakage.

I. Where modulating dampers are provided, take measurements and balance at extreme conditions.

J. Test and Balance Agency shall provide not less than the following:
   1. Test and adjust all fan RPM to design requirements.
   2. Test and record all fan motor full load amperes.
   3. Make Pitot Tube traverse of main supply, return and exhaust ducts and obtain design CFM at all supply, return and exhaust air fans.
   4. Test and record system static pressure, suction and discharge.
   5. Test and adjust system for design re-circulated air, CFM.
   6. Test and adjust system for design minimum CFM outside air by readings of return, outside and mixed air temperatures.
   7. Test and record entering air temperatures. (D.B. heating and cooling; W.B. cooling).
   8. Test and record leaving air temperatures. (D.B. heating and cooling; W.B. cooling).
   9. Adjust all main supply and return air ducts to proper design CFM.
   10. Adjust all zones and dampers to proper design CFM.
   11. Test and adjust each diffuser, grille, and register to within 5% of design requirements.

K. Each grille, diffuser and register shall be identified as to location and area.

L. Size, type and manufacture of diffusers, grilles, registers and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.

M. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.

N. In cooperation with the control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated and/or noted. All controls shall be checked for proper calibrations and all controls requiring adjustment by control installers shall be listed.

O. All diffusers, grilles, and registers shall be adjusted to minimize draft in all areas.

P. As a part of the work, the Contractor shall make any changes in the pulleys, belts, and dampers or the addition of dampers required for correct balance as required at no additional cost to Owner.

3.5 VARIABLE AIR VOLUME SYSTEMS (VAV)

A. Additional procedures required for balancing VAV systems are as follows, depending on whether the VAV controller is pressure dependent or pressure independent.

B. VAV Systems with Pressure Independent Volume Control Assemblies (Boxes)
   1. Set selected thermostats for box maximum airflow, and the remainder for minimum airflow, such that the sum total airflow rate of assemblies equals the fan design flow rate of assemblies equals the fan design flow rate. (Determined by diversity factor). System pressure controls may have to be reset so supply fan volume controller delivers design airflow rate.
   2. Test the inlet static pressure at several of the most difficult to supply boxes and make system adjustments for adequate pressure at the inlet of all assemblies to provide the required airflow rate.
   3. Proceed to balance the maximum airflow boxes and related downstream terminals according to procedure selected.
   4. Put one (1) maximum airflow box at a time on minimum flow. Test the minimum flow by calculations based on change of static pressure in the assembly discharge duct or by the sum of air terminal flows.
   5. Some controllers may require adjustment of maximum flow before minimum flow adjustment.
   6. Proceed to balance, one (1) at a time, all of the boxes which were set at minimum for diversity.
   7. With selected assemblies at maximum flow, and the remainder for minimum flow to suit diversity factor, measure and record the total supply and return airflow rates and also the supply system constant control led static pressure.
   8. Repeat (7) above with all assemblies set for minimum flow.
   9. Reset all controls for normal operation.

3.6 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.

5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.7 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated fittings or equipment and pressure gages to determine flow rates for system balance. Where not installed, base flow balance on temperature difference across heat transfer elements.

C. Effect system balance with automatic control valves fully open to heat transfer elements.

D. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings.

E. The Test & Balance Agency shall provide not less than the following for Phase One:
1. Open all valves to full open position. Close coil bypass stop valves.
2. Have contractor remove and clean all strainers.
3. Examine water in the hot water heating system and determine if water has been treated and cleaned.
4. Check pump rotation.
5. Check expansion tanks to determine that they are not air bound and the system is completely full of water.
6. Check all air vents at high points of water systems and determine all are installed and operating freely.
7. Check operating of automatic bypass valve.
8. Check temperatures and pressure of steam to design requirements.
9. Complete air balance must have been accomplished before actual water balance begins.

F. The Test and Balance Agency shall provide not less than the following for Phase Two:
1. Proceed to balance each hot water coil.
2. Upon completion of flow readings and adjustments at coils, mark all settings and record data.

G. Upon completion of Phases 1 and 2, the balance technician shall proceed with Phase 3 as follows:
1. After making adjustments to coils, recheck settings at pumps and boilers. Re-adjust if required.
2. Install pressure gauges on each coil, then read pressure drop through coil at set flow rate on call for full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.

H. Upon completion of Phase 3, the balancing engineer shall prepare on a neatly typed sheet, a listing of all items required by specifications. This shall be included in the complete test and balance report.

3.8 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:
   1. Solid-state circuitry with a piezoelectric accelerometer.
   2. Velocity range of 0.1 to 10 inches per second (2.5 to 254 mm/s).
   3. Displacement range of 1 to 100 mils (0.0254 to 2.54 mm).
   4. Frequency range of at least 0 to 1000 Hz.
   5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.
   1. Use a calibrator provided with the vibration meter.
   2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
   1. Turn off equipment in the building that might interfere with testing.
   2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp (2.2 kW).

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

   1. Pumps:

      a. Pump Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Pump Base: Top and side.
      d. Building: Floor.
      e. Piping: To and from the pump after flexible connections.

   2. Fans and HVAC Equipment with Fans:
      a. Fan Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Ductwork: To and from equipment after flexible connections.
      g. Piping: To and from equipment after flexible connections.

3. HVAC Equipment with Compressors:
    a. Compressor Bearing: Drive end and opposite end.
    b. Motor Bearing: Drive end and opposite end.
    c. Equipment Casing: Top and side.
    d. Equipment Base: Top and side.
    e. Building: Floor.
    f. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.
1. Verify that vibration isolation is installed in the required locations.
2. Verify that installation is level and plumb.
3. Verify that isolators are properly anchored.
4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.9 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 m/s), use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.
   1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

K. Perform sound testing at two locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.
   1. Private office.
   2. Open office area.
   3. Conference room.
   4. Auditorium/large meeting room/lecture hall.
   5. Classroom/training room.
   6. Inside mechanical equipment room.

3.10 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.11 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Notes to explain why certain final data in the body of reports varies from indicated values.
14. Test conditions for fans and pump performance forms including the following:
    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings including settings and percentage of maximum pitch diameter.
    e. Settings for supply-air, static-pressure controller.
    f. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.

f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
j. Number of belts, make, and size.
k. Number of filters, type, and size.

2. Motor Data:
a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Filter static-pressure differential in inches wg (Pa).
f. Preheat coil static-pressure differential in inches wg (Pa).
g. Cooling coil static-pressure differential in inches wg (Pa).
h. Heating coil static-pressure differential in inches wg (Pa).
i. Outside airflow in cfm (L/s).
j. Return airflow in cfm (L/s).
k. Outside-air damper position.
l. Return-air damper position.

G. Apparatus-Coil Test Reports:
1. Coil Data:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
    a. Airflow rate in cfm (L/s).
    b. Average face velocity in fpm (m/s).
    c. Air pressure drop in inches wg (Pa).
    d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
    e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
    f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
    g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
    h. Refrigerant expansion valve and refrigerant types.
    i. Refrigerant suction pressure in psig (kPa).
    j. Refrigerant suction temperature in deg F (deg C).

H. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Fuel type in input data.
    g. Output capacity in Btuh (kW).
    h. Ignition type.
    i. Burner-control types.
    j. Motor horsepower and rpm.
    k. Motor volts, phase, and hertz.
    l. Motor full-load amperage and service factor.
    m. Sheave make, size in inches (mm), and bore.
    n. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
2. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm (L/s).
    b. Entering-air temperature in deg F (deg C).
    c. Leaving-air temperature in deg F (deg C).
    d. Air temperature differential in deg F (deg C).
    e. Entering-air static pressure in inches wg (Pa).
    f. Leaving-air static pressure in inches wg (Pa).
    g. Air static-pressure differential in inches wg (Pa).
    h. Low-fire fuel input in Btuh (kW).
    i. High-fire fuel input in Btuh (kW).
    j. Manifold pressure in psig (kPa).
    k. High-temperature-limit setting in deg F (deg C).

l. Operating set point in Btuh (kW).
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btuh (kW).

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches (mm), and bore.
h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
2. Motor Data:
a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
g. Number of belts, make, and size.
3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).

j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

M. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Unit make and model number.
d. Compressor make.
e. Compressor model and serial numbers.
f. Refrigerant weight in lb (kg).
g. Low ambient temperature cutoff in deg F (deg C).

2. Test Data (Indicated and Actual Values):

a. Inlet-duct static pressure in inches wg (Pa).
b. Outlet-duct static pressure in inches wg (Pa).
c. Entering-air, dry-bulb temperature in deg F (deg C).
d. Leaving-air, dry-bulb temperature in deg F (deg C).
e. Control settings.
f. Unloader set points.
g. Low-pressure-cutout set point in psig (kPa).
h. High-pressure-cutout set point in psig (kPa).
i. Suction pressure in psig (kPa).
j. Suction temperature in deg F (deg C).
k. Condenser refrigerant pressure in psig (kPa).
l. Condenser refrigerant temperature in deg F (deg C).
m. Oil pressure in psig (kPa).
n. Oil temperature in deg F (deg C).
o. Voltage at each connection.
p. Amperage for each phase.
q. Kilowatt input.
r. Crankcase heater kilowatt.
s. Number of fans.
t. Condenser fan rpm.
u. Condenser fan airflow rate in cfm (L/s).
v. Condenser fan motor make, frame size, rpm, and horsepower.
w. Condenser fan motor voltage at each connection.
x. Condenser fan motor amperage for each phase.

N. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.

f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

O. Vibration Measurement Reports:
1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

P. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

Q. Indoor-Air Quality Measurement Reports for Each HVAC System:
   1. HVAC system designation.
   2. Date and time of test.
   3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
   4. Room number or similar description for each location.
   5. Measurements at each location.
   6. Observed deficiencies.

R. Instrument Calibration Reports:
   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.12 INSPECTIONS

A. Initial Inspection:
   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
   2. Randomly check the following for each system:
      a. Measure airflow of at least 10 percent of air outlets.
      b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
      c. Measure sound levels at two locations.
      d. Measure space pressure of at least 10 percent of locations.
      e. Verify that balancing devices are marked with final balance position.
      f. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:
   1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.
   2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.
   3. Owner shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
   4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 230700

MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Provide labor, materials, equipment, supervision, and incidental services as necessary to complete all MECHANICAL INSULATION work as indicated on the Drawings and specified herein, including, but not limited to:
   1. Piping insulation, jackets, lining, and accessories.
   2. Ductwork insulation, jackets, lining, and accessories.
   3. Equipment insulation, covering, and accessories.
   4. Breeching insulation and accessories.

1.3 QUALITY ASSURANCE

A. Use persons with experience and skill for this work.

B. Use materials that are approved for the type and location of the installation.

C. Use only materials that are fire resistive with a very low flame spread rating.

D. Use materials that are suitable for use in plenum spaces.

E. Coordinate insulation materials with pipe and duct materials.

1.4 SUBMITTALS

A. All submittals shall conform to previous sections of these specifications. Tabulated type product data sheets are to be clearly marked to indicate specific items.

B. Provide submittals on the following:
   1. Piping insulation, jackets, lining, and accessories.
   2. Ductwork insulation, jackets, lining, and accessories.
   3. Equipment insulation, covering, and accessories.
   4. Breeching insulation and accessories.

PART 2 - PRODUCTS

2.1 INSULATION MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Corp.
2. Certainteed Corp.
3. Knauf Corp.
4. Manville/Schuller
5. Owens-Corning Fiberglass Corp.
6. Rubatex Corp.

2.2 PIPE INSULATION

A. Glass Fiber Insulation shall be ANSI/ASTM C547; k value of 0.24 at 75^0F; noncombustible and used on domestic hot and cold water lines, roof drains, heating water supply and return steam and condensate lines, humidifier piping and cooling tower supply and return.

B. Cellular foam shall be flexible, plastic; k value of 0.28 at 75^0F and used on refrigerant hot gas and suction lines, and cold condensate lines. The insulation shall be capable of a water vapor permeability of .20 perms per inch maximum.

C. Jackets:

1. Vapor Barrier Jackets shall be Kraft reinforced foil vapor barrier with self-sealing adhesive joints.

2. PVC Jackets shall be one piece, premolded type.

3. Canvas jackets shall be UL listed treated cotton fabric, 6 oz/sq yd.

4. Aluminum jackets shall be ASTM B209; 0.020" thick; smooth finish.

5. Stainless Steel jackets shall be type 304/316 stainless steel; 0.010" thick; smooth finish.

D. Accessories:

1. Insulation bands shall be 3/4" wide; 0.010" thick galvanized steel. 0.015" thick aluminum.

2. Metal Jacket bands shall be 3/8" wide; 0.015" thick aluminum. 0.010" thick stainless steel.

3. Insulating cement shall be ANSI/ASTM C195; hydraulic setting for mineral wool.

4. Fibrous Glass cloth shall be untreated; 9 oz/sq yd weight.

2.3 EQUIPMENT INSULATION

A. Flexible Mineral Fiber blanket shall be ASTM C553; k value of 0.24 at 75^0F; 2.0 lb/cu ft density and used on air separators. The thickness shall be not less than 1".

B. Rigid Mineral Fiber board shall be ASTM C612; k value of 0.24 at 75^0F; 6.0 lb/cu ft density and used on domestic hot water storage tanks. The thickness shall be not less than $1^1/_2$".

C. Cellular glass shall be ASTM C552; k value of 0.35 at 75^0F; 8.0 lb/cu ft density.

D. Accessories:

1. Bedding compounds shall be non-shrinking, permanently flexible compatible with insulation.

2. Vapor Barrier coating shall be non-flammable, fire resistant, polymeric resin, compatible with insulation.
3. Insulating cement shall be ANSI/ASTM C195; hydraulic setting for mineral wool.
4. Wire mesh shall be corrosive-resistant metal; hexagonal pattern.

2.4 DUCTWORK INSULATION

A. Flexible Glass fiber shall be ASTM C553; commercial grade; k value of 0.29 at 75^0F; 0.002" foil scrim facing for air conditioning ducts and used on exhaust ducts within 10 ft of exterior openings, exhaust ducts exposed to outdoor air, ventilation equipment casings, and supply ducts (cooling system). The thickness shall be not less than $1^1/_2$".

B. Rigid Glass fiber shall be ASTM C612, Class 1; k value of 0.24 at 75^0F; 0.002" foil scrim facing for air conditioning ducts and used on combustion air duct, outside air intake ducts, plenums (cooling system), return duct, return and relief ducts in mechanical rooms, and outside supply and return duct. The thickness shall be not less than $1^1/_2$".

C. Indoor jackets shall be 8 oz/sq yd glass mesh; multi-purpose foil-scrim kraft; or pre-sized glass cloth, 8 oz sq/yd.

D. Outdoor jackets shall be 0.030" PVC sheet; .016 aluminum or mastic reinforced with glass mesh.

E. Accessories:

1. Adhesives shall be waterproof fire-retardant type.
2. Lagging adhesive shall be fire resistive.
3. Impale anchors shall be galvanized steel, 12 gauge, self-adhesive pad.
4. Joint tape shall be glass fiber cloth, open mesh.
5. Tie wire shall be annealed steel, 16 gauge.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping, ductwork, equipment, and breeching has been thoroughly tested and approved prior to installing insulation.

B. Clean all surfaces to be insulated for adhesives to insure proper bonding.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions and in a workmanlike manner.

B. Maintain ambient temperatures and conditions required by the manufacturers of the adhesive and the insulation.

C. Continue insulation vapor barrier through penetrations.

D. Pipe Insulation:

1. Locate insulation and cover seams in least visible locations.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. All ends, corners, edges, etc. shall be completely secured.

4. Cold pipe insulation requiring a vapor barrier shall have the vapor barrier continuous through fittings, valves, unions, flanges, strainers, and expansion joints.

5. Insulation not requiring a vapor barrier shall have exposed ends beveled and sealed with mastic at unions, flanges, etc.

6. Provide insert between support shield and piping, under the finish jacket, on piping 2" diameter or larger. Fabricate out of cork or other heavy density insulating material suitable for temperature, not less than 6" long, of the same thickness and contour as adjoining insulation. Shields and saddles shall be provided by piping installer.

E. Pipe Insulation Jackets:

1. Indoor, Concealed Hot Pipes shall have furnished standard factory-applied jackets with or without vapor barrier. Finish fittings, joints, and valves with glass cloth and adhesive. PVC jackets may be used.

2. Indoor, Concealed Cold Pipes shall be furnished with vapor barrier jackets, factory-applied. Finish fittings, joints, and valves with glass cloth and vapor barrier adhesive.

3. Indoor, exposed Pipes shall be finished with rewettable glass cloth and sized for finish painting. PVC jackets may be used.

4. Exterior Applications shall be furnished with vapor barrier jackets. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

F. Equipment Insulation:

1. Apply insulation as close as possible to equipment by grooving, scoring, and beveling insulation, if necessary. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands that will insure a tight secure installation.

2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

3. Cover insulation with metal mesh and finish with heavy coat of insulating cement. Flexible electrometric insulation may be finished with two coats of approved Finish reinforced with glass mesh.

4. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

5. When equipment with insulation requires periodic opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.

G. Ductwork Insulation:

1. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

2. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.

3. Secure insulation without vapor barrier with staples, tape, or wires.

4. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging.

5. Seal vapor barrier penetrations by mechanical fasteners, with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

6. Flexible electrometric thermal insulation may be used on exterior duct work when installed using compression fit method at joints and full adhesive coverage. Finish to be reinforced with glass mesh.

3.3 MINIMUM PIPE INSULATION

A. SERVICE WATER SYSTEMS

Fluid Temperatures	Non-circulating runouts	Circulating Mains & Runouts	Circulating Mains & Runouts	
	Up to 1"	Up to $1^1/_4$"	$1^1/_2$"-2"	Over 2"
40^0F-139^0F	0.5"	0.5"	0.5"	1.0"

NOTES:

1. Nominal iron pipe size and insulation thickness.
2. Conductivity K =.27
3. For recirculation systems, piping heat loss shall be limited to a maximum of 17.5 Btu/h per linear ft of pipe which is based on design external temperature no lower than 65^0F.
4. Design temperatures must be calculated.

B. RAIN CONDUCTORS

	Insulation Thickness
Horizontal Pipe	1.5”
Vertical Pipe	1.0”

NOTES:

1. Good for all pipe sizes.
2. Based upon R = 4.0 $ft^2/hr/^0F/Btu/in$
3. For the entire run of horizontal piping up to the vertical piping not in the building enclosure.
4. For the entire run of vertical piping where pipe is not enclosed in the building structure.

3.4 DUCT INSULATION

A. Minimum duct insulation in unconditioned or semi-conditioned attics.

Air	Minimum Thickness (Inches)
Supply	2"
Return	1"
Outside Air	2"

NOTES:

1. Based upon an R value of 4.0 $ft^2/^0F/Btu/in$.

B. Minimum duct insulation in conditioned spaces.

Air	Minimum Thickness (Inches)
Supply	1"
Return	0"
Outside Air	4"

NOTES:

1. Based upon an R value of 4.0 $ft^2/^0F$/Btu/in.

END OF SECTION

SECTION 23 09 23
DIRECT DIGITAL CONTROLS

PART 1: GENERAL

1.0 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Division 23 - Ductwork Accessories:
   1. Automatic Dampers

1.1 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Division 23 - Air Conditioning Equipment:
   1. Thermostats
   2. Sensors
   3. Controllers

1.2 PRODUCTS NOT FURNISHED OR INSTALLED BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. Division 23 –Air Conditioning Equipment
   1. Discharge Air Temperature Control
   2. Air volume control

1.3 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of these Specifications and shall be used in conjunction with this Section as a part of the Contract Documents. Consult them for further instructions pertaining to this work. The Contractor is bound by the provisions of Division 0 and Division 1.

1.4 DESCRIPTION

A. General: The control system shall be as indicated on the drawings and described in the specifications, and consist of a peer-to-peer network of digital building control panels and operator workstation(s). The user interface shall through any personal computer available on the network. The PC shall provide users an interface with the system though dynamic color graphics of building areas and systems.

B. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of systems defined for control on this project.

C. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited by operator ID and password. An operator shall be able to log onto any PC on the designated network and have access to all designated data.

D. The control system shall be designed such that each mechanical system will operate under stand-alone control. As such, in the event of a network communication failure, or the loss of other controllers, the control system shall continue to independently operate the unaffected equipment.

E. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. Internet connectivity may be provided for remote access to the system.

1.5 APPROVED CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS

A. Approved Control System Contractors and Manufacturers:
1. Airtech Automation
2. BASS Controls
3. Metro Controls, Inc.
4. Metro Environmental
5. Michigan Environmental Controls
6. Smart Building Services
7. The Trane Company Model Trane Tracer SC System.
8. OWNER approved equal.

B. The above list of manufacturers applies to user interface, controller software, custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.6 QUALITY ASSURANCE

A. System Installer Qualifications
1. The Installer shall have an established working relationship with the Control System Manufacturer of not less than three years.
2. The Installer shall have successfully completed Control System Manufacturer's classes on the control system. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.
3. The installer shall have an office within 30 miles of the project site and provide 24-hour response in the event of a customer call.

1.7 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of local, state and federal authorities. As a minimum, the installation shall comply with the current editions in effect 30 days prior to receipt of bids of the following codes:
1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Mechanical Code (IMC)
4. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
5. ANSI/ASHRAE Standard 135-2012 (BACnet)

1.8 SYSTEM PERFORMANCE

A. Performance Standards. The system shall conform to the following:

1. Page Display. The system shall display a web page will be displayed within 10 seconds of the request.
2. Page Refresh. The system shall update all within 10 seconds.
3. Graphic Refresh. The system shall update all dynamic points with current data within 30 seconds.
4. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds.-
5. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current, within the prior 60 seconds.
6. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 30 seconds.
7. Program Execution Frequency. Custom programs shall be capable of running as often as once every second. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
8. Performance. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Multiple Alarm Annunciation. All users on the network shall receive alarms within 10 seconds of each other.
10. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C [±1°F]
Ducted Air	±1.0°C [±2°F]
Outside Air	±1.0°C [±2°F]
Relative Humidity	±5% RH
Air Flow (terminal)	±10% of reading *Note 1
Air Flow (measuring stations)	±5% of reading
Air Pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air Pressure (space)	±3 Pa [±0.01 "W.G.]
Electrical Power	± 5% of reading *Note 3
Carbon Monoxide (CO)	± 5% of reading
Carbon Dioxide (CO2)	± 50 PPM

Note 1: (10%-100% of scale) (cannot read accurately below 10%)
Note 2: for both absolute and differential pressure
Note 3: * not including utility supplied meters

1.9 SUBMITTALS

A. Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications. Six (6) copies are required. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats.

B. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the contractor from furnishing quantities required for completion.

C. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.

D. Submit the following within 30 days of contract award:

1. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
2. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.
3. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:
   a) Building Controllers
   b) Custom Application Controllers
   c) Application Specific Controllers
   d) Operator Interface Computer Workstation
   e) Auxiliary Control Devices
   f) Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling
   g) Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled
   h) Points list showing all system objects, and the proposed English language object names
   i) Sequence of operations for each system under control. This sequence shall be specific for the use of the Control System being provided for this project
   j) Color prints of proposed graphics with a list of points for display

E. Project Record Documents. Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

1. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .DWG or .DXF drawing files shall also be provided.
2. Testing and Commissioning Reports and Checklists.
3. Operating and Maintenance (O & M) Manual. These shall be as-built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:

a) Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
b) Provide on-line help for documenting operator instructions
c) A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
d) One set of electronic media containing files of all color-graphic screens created for the project.
e) Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.
f) Licenses and warranty documents for all equipment and systems.
g) Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.

F. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer shall be completed at least 3 weeks prior to first class.

1.10 WARRANTY

A. Warrant all work as follows:
1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by Owner must, however, be granted prior to the installation of such changes.
4. The system provider shall provide a web-accessible system and support on-line resource that provides the Owner access to a question/answer forum, graphics library, user tips, upgrades, and manufacturer training schedules.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed hardware and software shall become the property of the Owner. These items include but are not limited to:
1. Project graphic images
2. Record drawings
3. Project database
4. Project-specific application programming code

5. All documentation

PART 2: PRODUCTS

2.0 MATERIALS

A. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 1 year. The installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing. Spare parts shall be available for at least 5 years after completion of this contract.

2.1 COMMUNICATION

A. This project shall comprise of a network utilizing high-speed BACnet for communications between System Controllers. . BACnet MSTP sub-networks shall be used for communications between System Controllers, Custom Application Controllers and Application Specific Controllers.

B. The Owner will provide all communication media, connectors, repeaters, network switches, and routers necessary for the internetwork. An active Ethernet jack will be provided adjacent to each System Control Panel and PC Workstation for connection to this network.

C. All System Controllers shall have an Ethernet communications port for connections with the operator interfaces

D. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:

1. Connection of an operator interface device to any one system controller on the internetwork will allow the operator to interface with all other system controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all system controllers shall be available for viewing and editing from any one system controller on the internetwork.
2. All database values (i.e., points, software variable, custom program variables) of any one system controller shall be readable by any other system controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a point name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communications services to perform internetwork value passing.

E. The time clocks in all system controllers shall be automatically synchronized daily.

2.2 OPERATOR INTERFACE

A. Operator Interface. The Enterprise wide network will be provided by the owner and supports the Internet Protocol (IP).

B. Workstation information shall be provided through web pages.

C. User Interface

1. User interface. The system user interface shall be web based graphically orientated. Provide a method for the operator to easily move between web pages. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation of equipment. Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog

outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.

2. Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.
3. Graphics Library. Furnish a library of standard HVAC equipment in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.
4. Engineering Units. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system. Unit selection shall be able to be customized by locality to select the desired units for each measurement. Engineering units on this project shall be Inch Pound.

D. System Applications. Each system controller shall provide storage of system information. Provide the following applications at each system controller.

1. Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
2. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all system functions and shall provide the relevant data for that particular screen. Additional help shall be available through the use of hypertext links onscreen.
3. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. All system security data shall be stored in an encrypted format.
4. System Diagnostics. The system shall automatically monitor the operation of all, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
5. Alarm Notification. Operator shall be notified of new alarm as they occur while navigating through any part of the system with an alarm icon. Alarm messages shall use full language, easily recognized descriptors for alarm. System will have the capability to acknowledge Alarms and add and save comments for the alarm.
6. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
7. Alarm Reactions. A user shall be able to determine what actions will occur if any, upon receipt of an alarm. Actions shall display on the screen, logging, start a custom control program, displaying messages, send a SMTP e-mail message that can be directly displayed on a smart phone, or forwarded to a cell phone via a text message. . Each of these actions shall be configurable by any PC and time of day. .
8. Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. The operator shall be able to sort and filter alarms from

events. Alarms shall be sorted in up to 4 categories based on severity. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be stored by the building controller. Provide a comment field in the event log that allows a user to add specific comments associated with any alarm.

9. Trend Logs. The system shall automatically create trend logs for a minimum of 5 key measurements for each controlled HVAC device. The automatic trend logs shall monitor these parameters for a minimum of 24 hours at 15 minute intervals. The automatic trend logs shall be user adjustable. A user shall also be able to define a trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Trend intervals shall be as frequently as 1minute up to yearly sampling and shall be selectable. Trend data shall be sampled and stored on the Building Controller panel and can be archived on a PC. Trend data shall be able to be viewed and printed from the operator interface software. Trends must be viewable in a text-based format or graphically. Trends shall also be storable in a CSV or PDF format for use by other industry standard word processing and spreadsheet packages. The following is a list of key measurements required for Trending:

Air Flow Set point Active

Air Valve Position Status

Cooling Capacity Status

Discharge Air Flow

Discharge Air Temperature

Discharge Air Temperature Set point Active

Duct Static Pressure Active

Duct Static Pressure Set point Active

Face and Bypass Damper Position Status

Primary Heat Output

Outdoor Air Damper Position

Outdoor Air Damper Position

Space Temperature Active

Space Temperature Set point Active

Active Cool/Heat Set point Temperature

Actual Running Capacity

Condenser Saturated Refrigerant Temperature Circuit 1

Condenser Saturated Refrigerant Temperature Circuit 2

Current Limit Setpoint

Demand Limit Setpoint

Discharge Saturated Refrigerant Temperature Circuit 1

Discharge Saturated Refrigerant Temperature Circuit 2

Operating Mode

Reheat Valve Status

Running Mode

Unit Power Consumption

10. Dynamic Graphical Trending. The system shall have the ability to save the data collected by a trend object and display that collected data in a graphical chart. Trend viewing capabilities shall include the ability to show up to 6 points on a chart, to include live and/or historical data. Each data point trend line shall be an individual color. Navigation and viewing functions shall include scrolling and zooming of x and y axes, and a trace display of the associated time stamp, and values for any selected point along the x-axis.
11. Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu, on graphics or through custom programs.
12. Clock Synchronization. A designated building controller shall synchronize all other building controllers on the network. A building controller shall also be able to synchronize with a NTP server for automatic time synchronization. The system shall automatically adjust for daylight savings time if applicable.
13. Reports and Logs. Provide a reporting package that allows the operator to select reports. A number of different reports shall be available to be selected by the user and provide current data. All reports can be set up to be run at specified intervals of time. Reports and logs shall be stored on the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. The operator shall be able to designate reports that shall be stored to disk at selectable intervals. Provide a means to list and access the last 10 reports viewed by the user.
    i. All Points in Alarm Report: Provide an on demand report showing all current alarms.
    ii. All Points in Override Report: Provide an on demand report showing all overrides in effect.
    iii. Commissioning Report: Provide a one time report that lists all equipment with the unit configuration and present operation.
    iv. Points report: Provide a report that lists the current value of all points

2.3 APPLICATION AND CONTROL SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator workstation.

B. System Security
    1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator
3. User logon/logoff attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

C. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:

1. Weekly Schedule. Provide separate schedules for each day of the week.
2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
3. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
4. Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less then and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

D. Remote Communications. The system shall have the ability to transmit alarms to multiple associated alarm receivers. Receivers shall include PC Workstations, email addresses, and cell phones. The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system utilizing the system Ethernet communications, or dial up communications via modem, in the same format and method used on site as described under the Operator Interface section of this specification.

E. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-wind-up shall be supplied. The algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs. The controlled variable, and set-point, shall be user-selectable. The set-point shall optionally be chosen to be a reset schedule.

F. Point control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events

G. Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, workstation, or the operator display. The amount of time that the override takes precedence will be selectable from the workstation.

H. Anti-Short Cycling. All binary output points shall be protected from short cycling.

2.4 SYSTEM CONTROLLERS

A. General. Provide System Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The System Automation System shall be composed of one or more independent, standalone, microprocessor based System Controllers to manage the global strategies described in System software section.
2. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
3. The controller shall provide a USB communications port for connection to a PC
4. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
5. Controllers that perform scheduling shall have a real time clock.
6. Data shall be shared between networked System Controllers.
7. The System Controller shall utilize industry recognized open standard protocols for communication to unit controllers.
8. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
   a) Assume a predetermined failure mode.
   b) Generate an alarm notification.
   c) Create a retrievable file of the state of all applicable memory locations at the time of the failure.
   d) Automatically reset the System Controller to return to a normal operating mode.

B. Communications. Each System Controller shall reside on the Enterprise wide network, which is same high-speed network as the workstations. The Enterprise wide network will be provided by the owner and supports the Internet Protocol (IP). Local connections of the System Controller shall be on ISO 8802-3 (Ethernet). Each System Controller shall also perform routing to a network of Custom Application and Application Specific Controllers [Optional – Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet MSTP as prescribed by the BACnet standard to perform communications to a network of Custom Application and Application Specific Controllers].

C. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 C to 50 C [-40 F to 122 F].

D. Serviceability. Provide diagnostic LEDs for power, communications, and processor. The System Controller shall have a display on the main board that indicates the current operating mode of the controller. All wiring connections shall be made to field removable, modular terminal connectors. The System controller shall utilize standard DIN mounting methods for installation and replacement.

E. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage

2.5 CUSTOM APPLICATION CONTROLLERS

A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.

1. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. Controllers that perform scheduling shall have a real time clock.
3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. The Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode, and generate an alarm notification.
5. Custom application controllers shall communicate using BACnet MSTP, ANSI/ASHRAE Standard 135-2004 (BACnet).

B. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient shall be mounted in IP 20 type enclosures, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].
2. Controllers used outdoors and/or in wet ambient shall be mounted within IP 56 type waterproof enclosures, and shall be rated for operation at -40 C to 70 C [-40 F to 158 F].

C. A local operator interface shall be provided at building locations where specified in the sequence of operations or point list. The operator interface shall be provided for interrogating and editing data. A system security password shall be available to prevent unauthorized use of the keypad and display.

D. Serviceability. Provide diagnostic LEDs for power, communications, and processor. All low voltage wiring connections shall be made such that the controller electronics can be removed and/or replaced without disconnection of field termination wiring.

E. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

F. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2.6 APPLICATION SPECIFIC CONTROLLERS

A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.

1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each ASC will contain sufficient I/O capacity to control the target system.

B. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controller used in conditioned ambient spaces shall be mounted in IP 20 type rated enclosures. Controllers located where not to be disturbed by System activity (such as above ceiling grid), may be provided with plenum-rated enclosures and non-enclosed

wiring connections for plenum cabling. All controllers shall be rated for operation at 0 C to 50 C [32 F to 120 F].

2. Controllers used outdoors and/or in wet ambient shall be mounted within IP 56 type waterproof enclosures, and shall be rated for operation at -40 C to 65 C [-40 F to 150 F].

C. Serviceability. Provide diagnostic LEDs for power and communications. All wiring connections shall be clearly labeled and made to be field removable.

D. Memory. The Application Specific Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.

E. Immunity to Power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

F. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.

G. Application specific controllers shall communicate using BACnet MSTP, ANSI/ASHRAE Standard 135-2004 (BACnet)

2.7 INPUT/OUTPUT INTERFACE

A. Hard-wired inputs and outputs may tie into the system through System, Custom, or Application Specific Controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 3 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.

E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 ma), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

F. Binary outputs shall provide for on/off operation. Terminal unit and zone control applications may use 2 outputs for drive-open, drive-close (tri-state) modulating control. Binary outputs on custom application controllers shall have 3-mode (on/off/auto) program override control from the panel with output status lights.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device. Analog outputs on custom application controllers shall have a 2-mode (auto/manual) program override control, with manual output adjustment over 0-100% of range.

2.8 AUXILIARY CONTROL DEVICES

A. Motorized dampers, unless otherwise specified elsewhere, shall be as follows:

1. Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.
2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
3. Damper shaft bearings shall be as recommended by manufacturer for application.
4. All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.
5. All leakage testing and pressure ratings will be based on AMCA Publication 500.
6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.

B. Control dampers shall be parallel or opposed blade types as scheduled on drawings.

C. Electric damper/valve actuators.

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
3. All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
6. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
7. Actuators shall be Underwriters Laboratories Standard 873 listed.
8. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.

D. Binary Temperature Devices

1. Low-Voltage Space Thermostats shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed set point adjustment, 13°C-30°C (55°F-85°F) set point range, 1°C (2°F) maximum differential, and vented cover.
2. Line-Voltage Space Thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed set point adjustment, 13°C-30°C (55°F-85°F) set point range, 1°C (2°F) maximum differential, and vented cover.
3. Low-Limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section

and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors

1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.
2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 1.5m [5 feet] in length.
3. Space sensors shall be equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings.
4. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.1 C [0.2 F].
5. [Optional] The space temperature, set point, and override confirmation will be annunciated by a digital display for each zone sensor. The set point will be selectable utilizing buttons.

F. Humidity Sensors

1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±5% R.H.
2. Duct sensors shall be provided with a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40 C to 75 C [-40 F to 170 F].
4. Humidity sensor's drift shall not exceed 1% of full scale per year.

G. Static Pressure Sensors

1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

H. Low Limit Thermostats

1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.
2. Low limit shall be manual reset only.

I. Carbon Dioxide (CO_2) Sensors

1. Carbon Dioxide sensors shall measure CO_2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 5 years. Sensors shall be duct or space mounted as indicated in the sequence of operation.

J. Relays

1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.
2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide IP 20 Type enclosure when not installed in local control panel.

K. Transformers and Power Supplies

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 70.0 mV maximum Peak-to-Peak. Regulation shall be 5% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
3. Unit shall operate between 0 C and 50 C.
4. Unit shall be UL recognized.

L. Current Switches

1. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

M. LOCAL CONTROL PANELS

1. All indoor control cabinets shall be fully enclosed IP 20 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
2. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide on/off power switch with over-current protection for control power sources to each local panel.

PART 3: EXECUTION

3.0 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.1 PROTECTION

A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.

B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.2 GENERAL WORKMANSHIP

A. Install equipment, piping, wiring/conduit parallel to system lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.3 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to System lines and properly supported.

C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

3.4 WIRING

A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence.

B. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:

C. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

D. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.

E. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

F. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.

G. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

H. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.

I. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

J. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

K. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.

L. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

M. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

N. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

O. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.5 FIBER OPTIC CABLE SYSTEM

A. All cabling shall be installed in a neat and workmanlike manner. Minimum cable and unjacketed fibber bend radii as specified by cable manufacturer shall be maintained.

B. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post installation residual cable tension shall be within cable manufacture's specifications.

C. Fiber optic cabinets, hardware, and cable entering the cabinet shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

3.6 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequate for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Install duct static pressure tap with tube end facing directly down-stream of air flow.

F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.

H. Wiring for space sensors shall be concealed in System walls. EMT conduit is acceptable within

I. Install outdoor air temperature sensors on north wall complete with sun shield at designated location.

3.7 ACTUATORS

A. Mount and link control damper actuators per manufacturer's instructions.

1. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.8 WARNING LABELS

A. Affix labels on each starter and equipment automatically controlled through the DDC System. Warning label shall indicate the following:

> CAUTION
>
> This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Affix labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects. Labels shall indicate the following:

> CAUTION
>
> This equipment is fed from more than one power source with separate disconnects.
> Disconnect all power sources before servicing.

3.9 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1-cm (1/2”) letters on nameplates.

D. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.10 CONTROLLERS

A. Provide a separate Controller for each major piece of HVAC equipment. A custom application controller may control more than one system provided that all points associated with that system are assigned to the same controller. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.

B. System Controllers and Custom Application Controllers shall be selected to provide a minimum of 10% spare I/O point capacity for each point type found at each location. If input points are not universal, 10% of each type is required. If outputs are not universal, 10% of each type is required. A minimum of one spare is required for each type of point used.

1. Future use of spare capacity shall require providing the field device, field wiring, points database definition, and custom software. No additional Controller boards or point modules shall be required to implement use of these spare points.

3.11 PROGRAMMING

A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming

1. Provide programming for the system as written in the specifications and adhere to the sequence strategies provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into any custom-written control programs sufficient comment statements or inherent flow diagrams to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface

1. Standard Graphics. Provide graphics for each major piece of equipment and floor plan in the System.
2. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.
3. As part of this execution phase, the controls contractor will perform a complete test of the operator interface. Test duration shall be a minimum of 8 hours on-site. Tests shall be made in the presence of the Owner or Owner's representative.

E. Demonstration: A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall dedicate a minimum of 16 hours on-site with the Owner and his representatives for a complete functional demonstration of all the system requirements. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation.

3.12 CLEANING

A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.13 TRAINING

A. Provide a minimum of 2 classroom training sessions, 4 hours each, throughout the contract period for personnel designated by the Owner.

B. Train the designated staff of Owner's representative and Owner to enable them to proficiently operate the system; create, modify and delete programming; add, remove and modify physical points for the system, and perform routine diagnostic and troubleshooting procedures.

C. Additional training shall be available in courses designed to meet objectives as divided into three logical groupings; participants may attend one or more of these, depending on the level of knowledge required:

1. Day-to-day Operators
2. Advanced Operators
3. System Managers/Administrators

D. Provide course outline and materials as per Part 1 of this Section. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of the installed hardware or at the customer's site.

G. This training shall be made available in addition to the interactive audio-visual tutorial, provided with the system.

3.14 ACCEPTANCE

A. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.

END OF SECTION

SECTION 231122

FACILITY FUEL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes fuel gas piping, specialties, and accessories within the building.

1.3 PROJECT CONDITIONS

A. Gas System Pressures: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2.0 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

B. Design values of fuel gas supplied for these systems are as follows:

1. Nominal Heating Value: 1000 Btu/cu. ft. (37.3 MJ/cu. m).
2. Nominal Specific Gravity: 0.6.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Corrugated, stainless-steel tubing systems. Include associated components.
2. Specialty valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Pressure regulators. Include pressure rating, capacity, and settings of selected models.

B. Shop Drawings: For fuel gas piping. Include plans and attachments to other Work.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

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

B. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."

C. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

D. IAS Standard: Provide components listed in IAS's "Directory of A. G. A. and C. G. A Certified Appliances and Accessories" if specified to be IAS listed.

E. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

F. Per ASME B 31.1, galvanized piping and fittings shall not be used with black steel piping and fittings in piping systems.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify fuel gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.7 COORDINATION

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Engineer's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Corrugated, Stainless-Steel Tubing Systems:
   a. Omega Flex, Inc.
   b. Titeflex Corp.
   c. Tru-Flex Metal Hose Corp.
   d. Ward Manufacturing, Inc.
2. Appliance Connector Valves:
   a. American Valve.
   b. Brass Craft Manufacturing Co.
   c. Conbraco Industries, Inc.; Apollo Div.
   d. Jomar International, Ltd.
   e. Mueller Co.; Mueller Gas Products Div.
   f. Watts Industries, Inc.; Water Products Div.
3. Gas Valves, NPS 2 (DN 50) and Smaller:
   a. Crane Valves.

b. Grinnell Corp.
c. Honeywell, Inc.
d. Jomar International, Ltd.
e. Milwaukee Valve Co., Inc.
f. Mueller Co.; Mueller Gas Products Div.
g. Nibco, Inc.
h. Red-White Valve Corp.
i. Watts Industries, Inc.; Water Products Div.

4. Plug Valves, NPS $2^{1}/_{2}$ (DN 65) and Larger:
   a. Flow Control Equipment, Inc.
   b. Milliken Valve Co., Inc.
   c. Nordstrom Valves, Inc.
   d. Olson Technologies, Inc.; Homestead Valve Div.
   e. Walworth Co.

5. Automatic Gas Valves:
   a. ASCO General Controls.
   b. Eaton Corp.; Controls Div.
   c. Eclipse Combustion, Inc.
   d. Honeywell, Inc.
   e. Johnson Controls, Inc.

6. Electrically Operated Gas Valves:
   a. ASCO General Controls.
   b. Eclipse Combustion Inc.
   c. Magnatrol Valve Corp.

7. Line Pressure Regulators:
   a. American Meter Co.
   b. Eclipse Combustion, Inc.
   c. Fisher Controls International, Inc.
   d. Maxitrol Co.
   e. Richards Industries, Inc.; Jordan Valve Div.
   f. Schlumberger Industries; Gas Div.

8. Appliance Pressure Regulators:
   a. Eaton Corp.; Controls Div.
   b. Harper Wyman Co.
   c. Maxitrol Co.
   d. SCP, Inc.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 CORRUGATED, STAINLESS-STEEL TUBING SYSTEMS

A. Description: Comply with AGA LC 1 and include the following:

1. Tubing: Corrugated stainless steel with plastic jacket or coating.
2. Fittings: Copper alloy with ends made to fit corrugated tubing. Include ends with threads according to ASME B1.20.1 if connection to threaded pipe or fittings is required.
3. Striker Plates: Steel, designed to protect tubing from penetrations.
4. Manifolds: Malleable iron or steel with protective coating. Include threaded connections according to ASME B1.20.1 for pipe inlet and corrugated tubing outlets.

2.4 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

A. Steel Pipe: ASTM A 53; Type E or S; Grade B; Schedule 40; black.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
3. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
4. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
5. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.
9. Phosphorus is prohibited.

B. Transition Fittings: Type, material, and end connections to match piping being joined.

2.5 PROTECTIVE COATING

A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in corrosive atmosphere.

2.6 PIPING SPECIALTIES

A. Flexible Connectors: ANSI Z21.24, copper alloy.

B. Quick-Disconnect Devices: ANSI Z21.41, convenience outlets and matching plug connector.

2.7 SPECIALTY VALVES

A. Valves, NPS 2 (DN 50) and smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS $2^1/_2$ (DN 65) and larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24.

C. Appliance Connector Valves: ANSI Z21.15 and IAS listed.

D. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig (13.8-kPa) minimum pressure rating.

E. Gas Valves, NPS 2 (DN 50) and smaller: ASME B16.33 and IAS-listed bronze body and 125-psig (860-kPa) pressure rating.

F. Plug Valves, NPS 2 1/2 (DN 65) and larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig (860-kPa) pressure rating.

G. General-Duty Valves, NPS 2 1/2 (DN 65) and larger: ASME B16.38, cast-iron body, suitable for fuel gas service, with "WOG" indicated on valve body, and 125-psig (860-kPa) pressure rating.

1. Gate Valves: MSS SP-70, OS&Y type with solid wedge.
2. Butterfly Valves: MSS SP-67, lug type with lever handle.

H. Automatic Gas Valves: ANSI Z21.21, with electrical or mechanical operator for actuation by appliance automatic shutoff device.

I. Electrically Operated Gas Valves: UL 429, bronze, aluminum, or cast-iron body solenoid valve; 120-V ac, 60 Hz, Class B, continuous-duty molded coil. Include NEMA ISC 6, Type 4, coil enclosure and electrically opened and closed dual coils. Valve position shall normally be closed.

2.8 PRESSURE REGULATORS

A. Description: Single stage and suitable for fuel gas service. Include steel jacket and corrosion-resistant components, elevation compensator, and atmospheric vent.

1. NPS 2 (DN 50) and smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2. NPS 2 1/2 (DN 65) and larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
3. Line Pressure Regulators: ANSI Z21.80 with 2-psig (13.8-kPa) minimum inlet pressure rating.
4. Appliance Pressure Regulators: ANSI Z21.18. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

B. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

PART 3 - EXECUTION

3.1 PREPARATION

A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.

B. Comply with ANSI Z223.1, "Prevention of Accidental Ignition" Paragraph.

3.2 PIPING APPLICATIONS

A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Fuel Gas Piping, 0.5 psig (3.45 kPa) or Less: Use the following:

1. NPS 3/4 and NPS 1 (DN 20 and DN 25): Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. NPS 3/4 and NPS 1 (DN 20 and DN 25): Corrugated, stainless-steel tubing system and threaded joints.
3. NPS 1 1/4 to NPS 2 (DN 32 to DN 50): Steel pipe, malleable-iron threaded fittings, and threaded joints.
4. NPS 2 1/2 to NPS 4 (DN 65 to DN 100): Steel pipe, malleable-iron threaded fittings, and threaded joints.
5. Larger than NPS 4 (DN 100): Steel pipe, steel welding fittings, and welded joints.

C. Fuel Gas Piping, 0.5 to 2 psig (3.45 to 13.8 kPa): Use the following:

1. NPS 3/4 and NPS 1 (DN 20 and DN 25): Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. NPS 3/4 and NPS 1 (DN 20 and DN 25): Corrugated, stainless-steel tubing system and threaded joints.
3. NPS 1 1/4 to NPS 2 (DN 32 to DN 50): Steel pipe, malleable-iron threaded fittings, and threaded joints.
4. NPS 2 1/2 to NPS 4 (DN 65 to DN 100): Steel pipe, malleable-iron threaded fittings, and threaded joints.
5. Larger than NPS 4 (DN 100): Steel pipe, steel welding fittings, and welded joints.

D. Containment Conduits: Steel pipe, steel welding fittings, and welded joints.

3.3 VALVE APPLICATIONS

A. Appliance Shutoff Valves for Pressure 0.5 psig (3.45 kPa) or Less: Appliance connector valve or gas stop.

B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig (3.45 to 13.8 kPa): Gas stop or gas valve.

C. Appliance Shutoff Valves for Pressure 2 to 5 psig (13.8 to 34.5 kPa): Gas valve.

D. Piping Line Valves, NPS 2 (DN 50) and Smaller: Gas valve.

E. Piping Line Valves, NPS 2 1/2 (DN 65) and Larger: Plug valve or general-duty valve.

3.4 PIPING INSTALLATION

A. Refer to other sections of these specifications for basic piping installation requirements.

B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.

2. In Floors: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in floors, subject to approval of authorities having jurisdiction. Surround piping cast in concrete slabs with minimum of 1-1/2 inches (40 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Gas piping may be installed in floor channels, subject to approval of authorities having jurisdiction. Channels must have cover and be open to space above cover for ventilation.
4. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.
    a. Exception: Tubing passing through partitions or walls.
5. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in masonry walls, subject to approval of authorities having jurisdiction.
6. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    a. Exception: Accessible above-ceiling space specified above.

C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches (75 mm) long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, unless indicated to be exposed to view.

E. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.

F. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

G. Connect branch piping from top or side of horizontal piping.

H. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

I. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.

J. Install corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

K. Install pressure gage upstream and downstream from each line pressure regulator.

L. Install flanges on valves, specialties, and equipment having NPS 2-1/2 (DN 65) and larger connections.

M. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

N. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches (100 mm) outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar, epoxy-polyamide paint according to SSPC-Paint 16.

3.5 JOINT CONSTRUCTION

A. Refer to other sections of these specifications for basic piping joint construction.

B. Use materials suitable for fuel gas.

3.6 HANGER AND SUPPORT INSTALLATION

A. Refer to other sections of these specifications for pipe hanger and support devices.

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

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).

3.7 CONNECTIONS

A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.

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

C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches (1800 mm) of each appliance. Install union downstream from valve.

D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

E. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
2. Do not use gas pipe as grounding electrode.

3.8 CLEANING

A. Flush hydronic piping systems with cleaning chemicals to rid the system of oils, flux and piping compounds used during installation. Then flush the system with clean water. Remove and clean

or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

3.9 PAINTING

A. Use materials and procedures specified in other sections of these specifications

B. Paint exterior pressure regulators and specialty valves, Gray.

3.10 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Engineer and authorities having jurisdiction.

D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.11 ADJUSTING

A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION

SECTION 232300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections include the following:

1. 07 92 00 Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
2. 23 05 29 Section "Hangers and Supports" for pipe supports and installation requirements.
3. 23 05 53 Section "Mechanical Identification" for labeling and identifying refrigerant piping.
4. 23 05 19 Section "Meters and Gages" for thermometers and pressure gages.

1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and pressure-regulating valves.

B. Shop Drawings: Show layout 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 relationship between piping and equipment.

1. Refrigerant piping indicated is schematic only. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

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

1.4 QUALITY ASSURANCE

A. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

B. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."

C. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."

1.5 COORDINATION

A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate pipe sleeve installations for penetrations in exterior walls and floor assemblies.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Refrigerants:
   a. Allied Signal, Inc./Fluorine Products; Genetron Refrigerants.
   b. DuPont Company; Fluorochemicals Div.
   c. Elf Atochem North America, Inc.; Fluorocarbon Div.
   d. ICI Americas Inc./ICI KLEA; Fluorochemicals Bus.
2. Refrigerant Valves and Specialties:
   a. Climate & Industrial Controls Group; Parker-Hannifin Corp.; Refrigeration & Air Conditioning Division.
   b. Danfoss Electronics, Inc.
   c. Emerson Electric Company; Alco Controls Div.
   d. Henry Valve Company.
   e. Sporlan Valve Company.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).

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

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

E. Bronze Filler Metals: AWS A5.8, Classification [BAg-1 (silver)] [BAg-2 (silver)]

2.3 VALVES

A. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.

B. Solenoid Valves: Comply with ARI 760; 250 deg F (121 deg C) temperature rating and 400-psig (2760-kPa) working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and solder-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2-inch (16-GRC) conduit adapter and 120 -V, normally [closed] [open] holding coil.

C. Pressure-Regulating Valves: Comply with ARI 770; direct acting, brass; with pilot operator, stainless-steel diaphragm, standard coil, and solder-end connection; suitable for refrigerant specified.

D. Pressure Relief Valves: Straight-through or angle pattern, brass body and disc, neoprene seat, and factory sealed and ASME labeled for standard pressure setting.

E. Thermostatic Expansion Valves: Comply with ARI 750; brass body with stainless-steel parts; thermostatic-adjustable, modulating type; size and operating characteristics as recommended by manufacturer of evaporator, and factory set for superheat requirements; solder-end connections; with sensing bulb, distributor having side connection for hot-gas bypass line, and external equalizer line.

F. Hot-Gas Bypass Valve: Pulsating-dampening design, stainless-steel bellows and polytetrafluoroethylene valve seat; adjustable; sized for capacity equal to last step of compressor unloading; with solder-end connections.

2.4 REFRIGERANT PIPING SPECIALITIES

A. Straight- or Angle-Type Strainers: 500-psig (3450-kPa) working pressure; forged-brass or steel body with stainless-steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8 inches (30 mm), 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.

B. Moisture/Liquid Indicators: 500-psig (3450-kPa) maximum working pressure and 200 deg F (93 deg C) operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.

C. Permanent Filter-Dryer: 350-psig (2410-kPa) maximum operating pressure and 225 deg F (107 deg C) maximum operating temperature; steel shell and wrought-copper fittings for solder-end connections; molded-felt core surrounded by desiccant.

2.5 REFRIGERANTS

A. ASHRAE 34, R-410A: Refrigerant Blend R-32/R-125 (50/50) (% by mass).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Aboveground, within Building: Type L (Type B) drawn-copper tubing.

B. Belowground for NPS 2 (DN 50) and Smaller: Type K (Type A) annealed-copper tubing.

3.2 VALVE APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor, for gage taps at hot-gas bypass regulators, on each side of strainers.

B. Install packed-angle valve in liquid line between receiver shutoff valve and thermostatic expansion valve for system charging.

C. Install diaphragm packless or packed-angle valves on each side of strainers and dryers, in liquid and suction lines at evaporators, and elsewhere as indicated.

D. Install a full-sized, three-valve bypass around each dryer.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve.
   1. Install solenoid valves in horizontal lines with coil at top.
   2. Electrical wiring for solenoid valves is specified in Division 26 Sections. Coordinate electrical requirements and connections.

F. Install thermostatic expansion valves as close as possible to evaporator.
   1. If refrigerant distributors are used, install them directly on expansion-valve outlet.
   2. Install valve so diaphragm case is warmer than bulb.
   3. 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.
   4. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install pressure-regulating and pressure relief valves as required by ASHRAE 15. Pipe pressure relief valve discharge to outside.

3.3 SPECIALTY APPLICATIONS

A. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.

B. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.

C. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.

D. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.

E. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.

3.4 PIPING INSTALLATION

A. Install refrigerant piping according to ASHRAE 15.

B. Basic piping installation requirements are specified in 23 05 00 Section "Basic Mechanical Materials and Methods."

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

D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.

E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

F. Belowground, install copper tubing in protective conduit. Vent conduit outdoors.

G. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

H. 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.

I. Install unions to allow removal of solenoid valves, pressure-regulating valves, and expansion valves and at connections to compressors and evaporators.

J. 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.

K. Hanger, support, and anchor products are specified in 23 05 29 Section "Hangers and Supports."

L. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6.0 m) long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6.0 m) or longer.
   3. Pipe rollers for multiple horizontal runs 20 feet (6.0 m) or longer, supported by a trapeze.
   4. Spring hangers to support vertical runs.

M. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).

N. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Braze joints according to 23 05 00 Section "Basic Mechanical Materials and Methods."

B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide) during brazing to prevent scale formation.

3.6 FIELD QUALITY CONTROL

A. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.
   1. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
   2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.
      a. System shall maintain test pressure at the manifold gage throughout duration of test.
      b. Test joints and fittings by brushing a small amount of soap and glycerine solution over joint.

c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.

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

3.7 ADJUSTING

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

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

C. Adjust set-point temperature of the conditioned air 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. Check compressor oil level above center of sight glass.
2. Open compressor suction and discharge valves.
3. Open refrigerant valves, except bypass valves that are used for other purposes.
4. Check compressor-motor alignment, and lubricate motors and bearings.

3.8 CLEANING

A. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.

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

3.9 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). 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 (14 kPa).
4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2" to plus 10" wg (minus 500 Pa to plus 2500 Pa). Metal ducts include the following:

1. Rectangular ducts and fittings.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 SUBMITTALS

A. Shop Drawings: CAD-generated and drawn to appropriate scale. Show fabrication and installation details for metal ducts.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.

2. Other systems installed in same space as ducts.
3. Ceiling and wall mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

1.5 QUALITY ASSURANCE

A. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

D. Tie Rods: Galvanized steel, 1/4" (6 mm) minimum diameter for lengths 36" (900 mm) or less; 3/8" (10 mm) minimum diameter for lengths longer than 36" (900 mm).

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Joint and Seam Tape: 2" (50 mm) wide; glass-fiber-reinforced fabric.

C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

E. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent release curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4" (100 mm) thick.
   2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4" (100 mm) thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

   1. Duct Size: Maximum 30" (750 mm) wide and up to 2" wg (500 Pa) pressure class.

   2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19" (480 mm) and larger and 0.0359" (0.9 mm) thick or less, with more than 10 sq ft (0.93 sq m) of nonbraced panel area unless ducts are lined.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts: 1" wg (250 Pa).
2. Supply Ducts (before Air Terminal Units): 2" wg (500 Pa).
3. Supply Ducts (after Air Terminal Units): 1" wg (250 Pa**)**].
4. Return Ducts (Negative Pressure): 1" wg (250 Pa).
5. Exhaust Ducts (Negative Pressure): 2" wg (500 Pa**)**.
6. All ducts shall be galvanized steel.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install ducts with fewest possible joints.

C. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12" (300 mm), with a minimum of 3 screws in each coupling.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1" (25 mm), plus allowance for insulation thickness.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

J. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

K. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

L. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least $1^1/_2$" (38 mm).

M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.

N. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes.

O. Protect duct interiors from the elements and foreign materials until building is enclosed.

P. Paint interiors of metal ducts, for ducts that do not have duct liner, for 24" (600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

1. For pressure classes lower than 2" wg (500 Pa), seal transverse joints.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24" (600 mm) of each elbow and within 48" (1200 mm) of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4" (100 mm) thick.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to other sections of these specifications.

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2" wg (500 Pa) (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2" to 10" wg (500 Pa to 2500 Pa).

4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.7 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

3.8 CLEANING EXISTING SYSTEMS

A. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Use existing service openings where possible.
2. Create other openings to comply with duct standards.
3. Disconnect flexible ducts as needed for cleaning and inspection.
4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
5. Remove and reinstall ceiling sections to gain access during the cleaning process.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide operative drainage system for washdown procedures.

7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Cleanliness Verification:

1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.

2. Visually inspect metal ducts for contaminants.

3. Where contaminants are discovered, re-clean and reinspect ducts.

G. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.

2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

H. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

END OF SECTION

SECTION 233300

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Backdraft dampers.
   2. Duct accessory hardware.
   3. Duct-mounting access doors.
   4. Filters.
   5. Fire dampers.
   6. Flexible connectors.
   7. Flexible ducts.
   8. Louvers.
   9. Motorized control dampers.
   10. Turning vanes.
   11. Volume dampers.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Backdraft dampers.
   2. Duct accessory hardware.
   3. Duct-mounting access doors.
   4. Filters.
   5. Fire dampers.
   6. Flexible connectors.
   7. Flexible ducts.
   8. Louvers.
   9. Motorized control dampers.
   10. Turning vanes.
   11. Volume dampers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Special fittings.
   2. Manual-volume damper installations.

3. Motorized-control damper installations.
4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4" (6 mm) minimum diameter for lengths 36" (900 mm) or less; 3/8" (10 mm) minimum diameter for lengths longer than 36" (900 mm).

2.3 BACKDRAFT DAMPERS

A. Manufacturers:
1. Air Balance, Inc.
2. American Warming and Ventilating.
3. Greenheck.
4. McGill AirFlow Corporation.
5. METALAIRE, Inc.
6. Nailor Industries, Inc.
7. Penn Ventilation Company, Inc.
8. Ruskin Company.

B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6" (150 mm) width, with sealed edges, assembled in rattle-free manner with 90-degree

stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.052" (1.3 mm) thick, galvanized sheet steel.

D. Blades: 0.025" (0.6 mm) thick, roll-formed aluminum.

E. Blade Seals: Neoprene.

F. Blade Axles: Non-ferrous

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. American Warming and Ventilating.
3. Greenheck.
4. McGill AirFlow Corporation.
5. METALAIRE, Inc.
6. Nailor Industries, Inc.
7. Penn Ventilation Company, Inc.
8. Ruskin Company.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3" wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside air stream and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064" (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064" (1.62 mm) thick, galvanized sheet steel.
3. Aluminum Frames: Hat-shaped, 0.10" (2.5 mm) thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10" (2.5 mm) thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050" (1.2 mm) thick extruded aluminum.
6. Blade Axles: Non-ferrous.
7. Bearings: Oil-impregnated bronze.
8. Tie Bars and Brackets: Aluminum.
9. Tie Bars and Brackets: Galvanized steel.

D. Low-Leakage Volume Dampers: Multiple or single-blade, parallel or opposed blade design as indicated, low-leakage rating, with linkage outside air stream and suitable for horizontal or vertical applications.
   1. Steel Frames: U-shaped, galvanized sheet steel channels, minimum of 0.064" (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   2. Roll-Formed Steel Blades: 0.064" (1.62 mm) thick, galvanized sheet steel.
   3. Aluminum Frames: U-shaped, 0.10" (2.5 mm) thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
   4. Roll-Formed Aluminum Blades: 0.10" (2.5 mm) thick aluminum sheet.
   5. Extruded-Aluminum Blades: 0.050" (1.2 mm) thick extruded aluminum.
   6. Blade Axles: Non-ferrous.
   7. Bearings: Oil-impregnated bronze thrust or ball.
   8. Blade Seals: Neoprene.
   9. Jamb Seals: Cambered aluminum.
   10. Tie Bars and Brackets: Galvanized steel.

E. Jackshaft: 1" (25 mm) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32" (2.4 mm) thick zinc-plated steel, and a 3/4" (19 mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.5 MOTORIZED CONTROL DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. Greenheck.
   4. McGill AirFlow Corporation.
   5. METALAIRE, Inc.
   6. Nailor Industries, Inc.
   7. Penn Ventilation Company, Inc.
   8. Ruskin Company.

B. General Description: AMCA-rated, opposed blade design; minimum of 0.1084" (2.8 mm) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635" (1.61 mm) thick, galvanized-steel damper blades with maximum blade width of 8" (203 mm).
   1. Secure blades to 1/2" (13 mm) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   2. Operating Temperature Range: From minus 40^0F to plus 200 ^{0}F (minus 40^0C to 93^0C).

3. Provide closed-cell neoprene edging.

2.6 FIRE DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. Greenheck.
   4. McGill AirFlow Corporation.
   5. METALAIRE, Inc.
   6. Nailor Industries, Inc.
   7. Penn Ventilation Company, Inc.
   8. Ruskin Company.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: $1^1/_2$hours.

D. Frame: Curtain type with blades outside air stream fabricated with roll-formed, 0.034" (0.85 mm) thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052" or 0.138" (1.3 mm or 3.5 mm) thick as indicated and of length to suit application.
   2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034" (0.85 mm) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034" (0.85 mm) thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 165^0F (74^0C) rated.

2.7 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate $1^1/_2$" (38 mm) wide, double vane, curved blades of galvanized sheet steel set 3/4" (19 mm) o.c.; support with bars perpendicular to blades set 2" (50 mm) o.c. and set into vane runners suitable for duct mounting.

2.8 DUCT-MOUNTING ACCESS DOORS

A. Manufacturers:
   a. Air Balance, Inc.
   b. American Warming and Ventilating.
   c. Greenheck.
   d. McGill AirFlow Corporation.

e. METALAIRE, Inc.
f. Nailor Industries, Inc.
g. Penn Ventilation Company, Inc.
h. Ruskin Company.

B. General Description: Fabricate doors airtight and suitable for duct pressure class.

C. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1" by 1" (25 mm by 25 mm) butt or piano hinge and cam latches.

D. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   a. Provide number of hinges and locks as follows:
      1) Less Than 12" (300 mm) Square: Secure with two sash locks.
      2) Up to 18"(450 mm) Square: Two hinges and two sash locks.
      3) Up to 24" by 48" (600 mm by 1200 mm): Three hinges and two compression latches with outside and inside handles.
      4) Sizes 24" by 48" (600 mm by 1200 mm) and Larger: One additional hinge.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. Ventfabrics, Inc.
   4. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip [3 1/2" (89 mm)] [5 3/4" (146 mm)] wide attached to two strips of 2 3/4" (70-mm-) wide, 0.028" (0.7 mm) thick, galvanized sheet steel or 0.032" (0.8 mm) thick aluminum sheets. Select metal compatible with ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq yd (880 g/sq m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40^{0}F to plus 200^{0}F (Minus 40^{0}C to plus 93^{0}C).

2.10 FLEXIBLE DUCTS

A. Manufacturers:
   1. Flexmaster U.S.A., Inc.
   2. Hart & Cooley, Inc.
   3. McGill AirFlow Corporation.

B. Non-insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
   1. Pressure Rating: 10" wg (2500 Pa) positive and 1.0" wg (250 Pa) negative.

2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
3. Temperature Range: Minus 10^0F to plus 160^0F (Minus 23^0C to plus 71^0C).

C. Noninsulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.
1. Pressure Rating:4" wg (1000 Pa) positive and 0.5" wg (125 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
3. Temperature Range: Minus 20^0F to plus 175^0F (Minus 28^0C to plus 79^0C).

D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3" through 18" (75 mm to 450 mm) to suit duct size.

2.11 FILTERS

A. Acceptable manufacturers:
1. American Air Filter
2. Farr Filters
3. Air Filter Manufacturing Co.

B. Disposable extended area panel filters shall be pleated, reinforced cotton fabric; supported and bonded to welded wire grid; enclosed in cardboard frame; nominal size 24" x 24" x 1" thick; rated 25%-30% dust spot efficiency.

C. Disposable panel filters shall be 2" thick glass fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive; nominal size 24" x 24" in cardboard frame with perforated metal retainer.

D. Filter frames shall be galvanized steel or extruded aluminum T-section construction with necessary gasketing between frames and walls.

E. Filter gauges shall be direct reading dial $3^1/_2$" inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, range 0-2.0" WG, 3% of full scale accuracy.

2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

E. Provide test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

G. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
   1. On both sides of duct coils.
   2. Downstream from volume dampers**,** turning vanes and equipment.
   3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
   4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50 foot (15 m) spacing.
   5. On sides of ducts where adequate clearance is available.

H. Install the following sizes for duct-mounting, rectangular access doors:
   1. One-Hand or Inspection Access: 8" by 5" (200 mm by 125 mm).
   2. Two-Hand Access: 12" by 6" (300 mm by 150 mm).
   3. Head and Hand Access: 18" by 10" (460 mm by 250 mm).
   4. Head and Shoulders Access: 21" by 14" (530 mm by 355 mm).
   5. Body Access: 25" by 14" (635 mm by 355 mm).
   6. Body Plus Ladder Access: 25" by 17" (635 mm by 430 mm).

I. Label access doors.

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. For fans developing static pressures of 5" wg (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Connect terminal units to supply ducts directly or with maximum 12" (300 mm) lengths of flexible duct. Do not use flexible ducts to change directions.

M. Connect diffusers to low pressure ducts directly or with maximum 60" (1500 mm) lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with draw bands.

O. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in other sections of these specifications.

END OF SECTION

SECTION 233416

CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes centrifugal fans and vent sets.

1.3 PERFORMANCE REQUIREMENTS

A. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material gauges and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Maintenance Data: For centrifugal fans to include in maintenance manuals specified in other sections of these specifications.

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. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Chicago Blower Corp.
4. Cook, Loren Company.
5. Greenheck

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, assembled, tested, and finished, belt driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

2.3 HOUSINGS

A. Materials and Fabrication: Formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components. Use galvanized steel to fabricate fans downstream from humidifiers.

1. Panel Bracing: Steel angle or channel iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Fabrication Class: AMCA 99, Class I
3. Horizontal Flanged Split Housing: Bolted construction.

B. Coatings: Hot-dip galvanized.

2.4 WHEELS

A. Backward-Inclined Fan Wheels: Steel construction with curved inlet flange, back plate, backward-inclined blades welded or riveted to flange and back plate**;** cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

B. Forward-Curved Fan Wheels: Black-enameled or galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.

C. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange; heavy back plate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

D. Coatings: Hot-dip galvanized.

2.5 SHAFTS

A. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

B. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

C. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2.6 BEARINGS

A. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 120,000 hours.

B. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 120,000 hours.

C. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 120,000 hours.
   2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 120,000 hours.

2.7 BELT DRIVES

A. Description: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor: 1.5.

B. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

C. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

D. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
   1. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 0.1046" (2.7 mm) thick, 3/4" (20 mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

E. Motor Mount: Adjustable for belt tensioning.

2.8 ACCESSORIES

A. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.

B. Companion Flanges: Galvanized steel, for duct connections.

C. Discharge Dampers: Heavy-duty steel assembly with opposed blades constructed of two (2) plates formed around and welded to shaft, channel frame, sealed ball bearings, with blades linked outside of air stream to single control lever.

D. Inlet Screens: Galvanized steel welded grid screen.

E. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.

F. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

G. Spark-Resistant Construction: AMCA 99.

H. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

I. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.9 MOTORS

A. Enclosure Type: Guarded drip proof or totally enclosed, fan cooled as determined by the Engineer for the environment.

2.10 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Install units with clearances for service and maintenance.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other sections of these specifications. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Verify lubrication for bearings and other moving parts.
   6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:
   1. Energize motor and adjust fan to indicated rpm.
   2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to other sections of these specifications for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION

SECTION 233600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Variable air volume (VAV) terminal units

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, and method of field assembly, components, and location and size of each field connection.
   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in other sections of these specifications include the following:
   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated.

B. 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.

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 VARIABLE AIR VOLUME TERMINAL UNITS

A. Acceptable manufacturers:
   1. Carrier
   2. Price Industries.
   3. Titus.
   4. Trane Co.
   5. Tuttle & Bailey.

B. Type shall be ceiling mounted, pressure independent, variable air volume supply air control terminals for connection to single medium pressure duct central air systems, with electric heating coils.

C. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

D. Identification shall be clearly marked with label and airflow indicator, including unit nominal air flow, maximum factory set air flow, minimum factory set air flow, and coil type.

E. Casing: 0.034-inch (0.85-mm) steel.
   1. Casing Lining: Adhesive attached, 1 inch (25 mm) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84 and meeting NFPA 90A requirements and UL 181 erosion requirements.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

F. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
   1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
   2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

G. Volume Damper: Constructed from extruded aluminum or galvanized steel components. Key damper blades into shaft with nylon fitted pivot points with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 6-inch wg (1500-Pa) inlet static pressure.
2. Damper Position: Actuator shall be externally mounted to position damper normally open.
3. Automatic Damper Operator to operate air volume damper:

H. Electric Heating Coil: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:
1. Primary and secondary over-temperature protection.
2. Nickel chrome 80/20 heating elements.
3. Airflow switch.
4. Fan interlock contact for fan powered terminal units.
5. Noninterlocking disconnect switch.
6. Fuses (for coils more than 48 A).
7. Mercury contactors.
8. Magnetic contactor for each step of control (for three-phase coils).
9. Heating coils shall be removable without removing the terminal unit.

I. Room Sensor: Electric wall mounting, with temperature set-point adjustment and proportional reheat coil control.

J. System Powered Controls:
1. Factory mounted and piped 5 micron filter, velocity resetting adjustable high limit control and amplifying relay.
2. Wall mounted thermostats.

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance. Support terminal units individually from structure. Do not support from adjacent ductwork.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other sections of these specifications. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect ducts to air terminal units according to other sections of these specifications.

C. Connect wiring according to other sections of these specifications.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect**,** test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
      a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
      b. Verify that controls and control enclosure are accessible.
      c. Verify that control connections are complete.
      d. Verify that nameplate and identification tag are visible.
      e. Verify that controls respond to inputs as specified.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

SECTION 233713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes Ceiling- and Wall-mounted Diffusers, Registers, and Grilles.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Products: Subject to compliance with requirements, provide one (1) of the products specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 GRILLES AND REGISTERS

A. Adjustable Bar Grilles and Register:

1. Products and manufacturers:
   a. Price Industries;
   b. Titus
2. Material: Steel.
3. Finish: Baked enamel, color selected by Engineer.
4. Face Blade Arrangement: Adjustable horizontal spaced 3/4" (19 mm) apart.
5. Rear Blade Arrangement: Adjustable vertical spaced 3/4" (19 mm) apart.
6. Frame: 1" (25 mm) wide.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed-blade assembly.
9. Accessories: Front blade gang operator.

2.3 CEILING DIFFUSER OUTLETS

A. Rectangular and Square Ceiling Diffusers:
   1. Products and manufacturer:
      a. Price Industries;
      b. Titus
   2. Material: Steel.
   3. Finish: Baked enamel, color selected by Engineer.
   4. Face Blade Arrangement: Adjustable horizontal spaced 3/4" (19 mm) apart.
   5. Rear Blade Arrangement: Adjustable vertical spaced 3/4" (19 mm) apart.
   6. Frame: 1" (25 mm) wide.
   7. Mounting: Countersunk screw.
   8. Damper Type: Adjustable opposed-blade assembly.
   9. Accessories:
      a. Equaling grid.
      b. Operating rod extension.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where Architectural features or other items conflict with installation, notify Engineer for a determination of final location.

C. Connect diffusers to low pressure ducts with five (5) foot maximum length of flexible duct. Hold in place with strap or clamp.

D. Check location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

E. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 237223
PACKAGED AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Packaged air-to-air Energy recovery units **(PART OF RTU-2 & RTU-4).** See Spec section 237413 for Packaged Rooftop Air Conditioning Units.

B. Casing.

C. Fans.

D. Total energy wheel.

E. Filters.

F. Vibration isolation.

G. Roof curbs.

H. Power and controls.

I. Accessories.

J. Service accessories.

1.02 RELATED REQUIREMENTS

A. Section 077200 - Roof Accessories: Roof curb.

B. Section 099113 - Exterior Painting.

1.03 REFERENCE STANDARDS

A. AHRI 1060 (I-P) - Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment; 2023.

B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2017, with Addendum (2022).

C. ASHRAE Std 84 - Method of Testing Air-to-Air Heat/Energy Exchangers; 2020, with Errata (2021).

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023c.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

A. See Section 013000 - Administrative Requirements for submittal procedures.

B. Product Data: Manufacturer's installation instruction, product data, and engineering calculations.

C. Shop Drawings: Show design and assembly of energy recovery unit and installation and connection details.

D. Manufacturer's Qualification Statement.

E. Closeout Submittals: Submit manufacturer's operation and maintenance instructions.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Firm regularly engaged in manufacturing energy recovery units.
   2. Products in satisfactory use in similar service for not less than five years.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in manufacturer's unopened packaging.

B. Store products to be installed indoors in dry, heated area.

1.07 WARRANTY

A. See Section 017800 - Closeout Submittals for additional warranty requirements.

B. Warranty energy recovery wheel to be free from defects in material and workmanship for 3 years under circumstances of normal use.

C. Warranty motor to be free from defects in material and workmanship for 7 years under circumstances of normal use.

D. Warranty dessicant core to be free from defects in material and workmanship for 5 years under circumstances of normal use.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Air-to-air Energy recovery units:
   1. RenewAire: www.renewaire.com/#sle.
   2. Semco Inc.: www.semcohvac.com/#sle.
   3. AAON.

B. Basis of Design: AAON

2.02 ENERGY RECOVERY UNITS

A. Energy Recovery Units: Provide dessicant wheel type or stationary core air-to-air exchanger; prefabricated packaged system designed by manufacturer.
   1. Provide unit with a AHRI 1060 (I-P) compliant air-to-air exchanger.
   2. Access: Hinged and/or screwed access panels on front.
   3. Lifting holes at the unit base.
   4. Framing: Welded extruded aluminum tubular frame capable of supporting components and casings.
   5. Permanent name plate listing manufacturer mounted inside door near electrical panel.

2.03 CASING

A. Wall, Floor, and Roof Panels:
   1. Construction: 1 inch (25 mm) thick, double wall box construction, with formed edges of exterior wall overlapping formed edges of interior wall.
   2. Exterior Wall: Galvanized steel sheet.
      a. 0.040 inches (1 mm) thick aluminum.
      b. Color: Gray.
   3. Interior Wall: Galvanized sheet metal.
      a. 22 gauge, 0.0299 inch (0.76 mm) galvanized sheet metal.
   4. Insulation:
      a. 1/2 inch (13 mm) insulated fiberglass.
      b. Panel Cores: Mineral wool board.
      c. Flame Spread Index (FSI): 25 or less, when tested in accordance with ASTM E84 or UL 723.
      d. Smoke Developed Index (SDI): 50, maximum, when tested in accordance with ASTM E84 or UL 723.

5. Roof Panel: Weatherproof.
6. Fasteners: Stainless steel.
7. Coating: Polyurethane enamel.

B. Access Panels: Provide access to components through a large, tightly sealed and easily removable panel.

C. Doors:
1. Construct doors of same construction and thickness as wall panels.
2. Height: 80 inches (2032 mm).

D. Weather Hood: Provide on fresh air inlet and exhaust air outlet; removable for access.
1. Fresh Air Weather Hood: Maintain a face velocity less than 340 feet/min (1.6 m/s).

2.04 FANS

A. Provide separate fans for exhaust and supply blowers.

B. Fans:
1. Individually driven with a dedicated motor.
2. Backward inclined.
3. AMCA-rated.
4. Provide with non-overloading characteristics.

C. Bearings:
1. Pillow block.
2. Bearings: Permanently lubricated sealed ball bearings.
3. Rated for not less than 200,000 hours of operation with accessible greased fittings.

D. Housings: 12 gauge, 0.1046 inch (2.66 mm) aluminized steel with plenums integral to general housing and constructed to Class 1 fan standards.

E. Motors:
1. Motors: Open drip proof.
2. Efficiency: High.
3. Speed: Single.
4. Control: Constant Speed.
5. Fan Motor: UL listed and labeled.

F. Drives:
1. Fans: Direct driven.
2. Horsepower: See Equipment Schedule on drawing.
3. Service Factor: 1.2.

2.05 TOTAL ENERGY WHEEL

A. Wheel: Transfer heat and humidity from one air stream to the other with minimum carryover of the exhaust air into the supply air stream.

B. Sensible Recovery Efficiency: 70%

C. Latent Recovery Efficiency: 60%.

D. Wheel Effectiveness: Rated in accordance with ASHRAE Std 84 and AHRI 1060 (I-P).

E. Flame Spread Index (FSI): 25 or less, when tested in accordance with ASTM E84 or UL 723.

F. Smoke Developed Index (SDI): 50 or less, when tested in accordance with ASTM E84 or UL 723.

G. Energy Recovery Wheel Media Face:
1. Comply with NFPA 90A.

H. Rotor:
1. Type: Non-segmented hygroscopic aluminum wheel.

2. Rotor Matrix: Corrosion resistant aluminum alloy composed of alternating corrugated and flat, continuously wound layers of uniform widths.

I. Desiccant:
1. Type: 3A.

J. Drive:
1. Drive: Tensioned drive with full perimeter link style belt.

2.06 FILTERS

A. Pre Filter: 2" Pleated Unit - MERV 7 and Metal Mesh OA Filters and Heat Wheel Exhaust Air Filters.

B. Unit Filter: 4" Pleated - 85% Efficiency - MERV 13.

C. Exhaust and Fresh Air Streams: MERV 7 filters constructed to meet ASHRAE Std 52.2.

D. Mount 1/2-inch (13 mm) thick, permanent, aluminum, washable type filter in outside air hood and in return air plenum.

2.07 VIBRATION ISOLATION

A. Vibration Isolation: Provide whole unit vibration isolation with the energy recovery unit assembly.

2.08 ROOF CURBS

A. Curbs: Provide full perimeter roof curb fabricated from 10 gauge, 0.1345 inch (3.42 mm) aluminized steel. Air-to-Air Energy Recovery Unit is part of RTU-2 and RTU-4. See Mechanical Schedule on Drawing for details.
1. Curbs: Knock-down type.
2. Provide flat for roof deck.

2.09 POWER AND CONTROLS

A. Motor Control Panels: UL listed.

B. Include necessary motor starters, fuses, transformers and overload protection according to NFPA 70.

C. Install wiring in accordance with NFPA 70.

2.10 ACCESSORIES

A. Freeze Protection Thermostat:
1. Equip unit with thermostat such that unit can be stopped when temperature drops to 23 degrees F (minus 5 degrees C).

2.11 SERVICE ACCESSORIES

A. Internal Service Lights: Provide vapor tight light with protective cage and minimum 40 watt bulb.

B. Electrical Receptacle:
1. Provide duplex, ground fault interrupter type receptacle.

C. Electrical Components: Factory wired for single point power connection.
1. 60 Hz power connection.

PART 3 EXECUTION

3.01 EXAMINATION

3.02 INSTALLATION

A. Provide openings for suitable ductwork connection.

B. Outdoor Installations:
   1. Roof Panels:
      a. Fasteners: Use concealed means of attachment.
      b. Minimize penetrations through roof.
      c. Provide weather tight seal at required penetrations.
   2. Do not locate roof panel joints above doors.

3.03 SYSTEM STARTUP

A. Provide services of manufacturer's authorized representative to provide start up of unit.

3.04 CLEANING

A. Clean filters, air plenums, interior and exposed-to-view surfaces prior to Substantial Completion.

END OF SECTION

SECTION 237413

ROOFTOP AIR CONDITIONING UNIT

PART 1 - GENERAL

1.01 Related Documents

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

1.02 SUMMARY

A. This Section includes the following rooftop air conditioning Units:
   1. **RTU-3:** Cooling and heating units 7 ½ to 20 tons (26 to 70 kW).
   2. **RTU-2 and RTU-4:** Cooling and heating units 7 ½ to 20 tons (26 to 70 kW) associated with Air-to-Air Energy Recovery Units. See **Section 237223** for packaged Air-to-Air Energy Recovery Units.

1.03 DEFINITIONS

A. DDC: Direct-digital controls.

1.04 SUBMITTALS

A. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:
   1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
   2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   3. Wiring Diagrams: Power, signal, and control wiring.

B. Operation and Maintenance Data: For rooftop air conditioners to include in emergency, operation, and maintenance manuals.

C. Warranties: Special warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop air conditioners and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. 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.

C. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

D. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

F. Comply with NFPA 54 for gas-fired furnace section.

G. ARI Certification: Units shall be ARI certified and listed.

H. ARI Compliance for Units with Capacities Less Than 135,000 Btuh (39.6 kW): Rate rooftop air-conditioner capacity according to ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment."
   1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

I. ARI Compliance for Units with Capacities 135,000 Btuh (39.6 kW) and More: Rate rooftop air-conditioner capacity according to ARI 340/360, "Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment."
   1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

1.06 COORDINATION

A. Coordinate size, location, and installation of rooftop air-conditioner manufacturer's roof curbs and equipment supports with roof installer.

1.07 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of rooftop air conditioners that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
   2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
   3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion.
   4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion.
   5. Warranty Period for Variable-Speed Fan Motors: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion.
   6. Warranty Period for Electronic Thermostats: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 ROOFTOP AIR CONDITIONERS 7 1/2 TO 20 TONS (26 TO 70 kW)

A. Manufacturers:
   1. AAON, Inc.
   2. Carrier Corp.
   3. Trane Company.
   4. Johnson Controls Inc. (YORK).

B. Description: Factory assembled and tested; designed for exterior installation; consisting of compressor, indoor and outside refrigerant coils, indoor fan and outside coil fan, refrigeration and temperature controls, filters, and dampers.

C. Casing: Galvanized-steel construction with enamel paint finish, removable panels or access doors with neoprene gaskets for inspection and access to internal parts, minimum 1" (25 mm) thick thermal insulation, knockouts for electrical and piping connections, exterior condensate drain connection, and lifting lugs.

D. Indoor Fan: Backward curved, plenum type, direct driven, grease-lubricated ball bearings, and motor.

E. Outside Coil Fan: Propeller type, directly driven by permanently lubricated motor.

F. Refrigerant Coils: Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor. Provide phenolic epoxy corrosion-protection coating to both coils.

G. Compressor(s): (Number as scheduled) scroll compressors with integral vibration isolators, internal overcurrent and over temperature protection, internal pressure relief, and crankcase heaters.

H. Refrigeration System:
   1. Compressor(s).
   2. Outside coil and fan.
   3. Indoor coil and fan.
   4. Check valves.
   5. Expansion valves with replaceable thermostatic elements.
   6. Refrigerant dryers.
   7. High-pressure switches.
   8. Low-pressure switches.
   9. Thermostats for coil freeze-up protection during low-ambient temperature operation or loss of air.
   10. Independent refrigerant circuits.
   11. Brass service valves installed in discharge and liquid lines.
   12. Charge of refrigerant.
   13. Hot-Gas Bypass: Factory-installed valve.
   14. Timed Off Control: Automatic-reset control shuts compressor off after five minutes.

I. Filters 2” thick, MERV 7 fiberglass throwaway Pre-filters in filter rack and 4” thick, MERV 13 Pleated type final filter.

J. Heat Exchanger: Stainless-steel construction for natural-gas-fired burners with the following controls:
   1. Redundant dual gas valve with manual shutoff.
   2. Direct-spark pilot ignition.
   3. Electronic flame sensor.
   4. Induced-draft blower.
   5. Flame rollout switch.

K. Economizer: Return- and outside-air dampers with neoprene seals, outside-air filter, and hood.
   1. Damper Motor: Fully modulating spring return with adjustable minimum position.
   2. Control: Electronic-control system uses outside-air enthalpy to adjust mixing dampers.
   3. Relief Damper: Gravity actuated with bird screen and hood.

L. Power Connection: Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in circuit breaker.

M. Unit Controls: Solid-state control board and components contain at least the following features:
   1. Indoor fan on/off delay.
   2. Default control to ensure proper operation after power interruption.
   3. Service relay output.
   4. Unit diagnostics and diagnostic code storage.
   5. Field-adjustable control parameters.
   6. Economizer control.
   7. Gas valve delay between first- and second-stage firing.
   8. Low-ambient control, allowing operation down to 00F (minus 180C).
   9. Minimum run time.
   10. Return-air temperature limit.
   11. Smoke alarm with smoke detector installed in supply and return air.
   12. Low-refrigerant pressure control.
   13. Digital display of outside temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
   14. Variable-Air-Volume Control: Variable-frequency drive controls supply-air static pressure.

N. Electromechanical Thermostat: Staged heating and cooling on subbase with manual system switch (on-heat-auto-cool) and fan switch (auto-on).
   1. Fan-proving switch to lock out unit if fan fails.

O. Optional Accessories:
   1. Service Outlets: Two, 115V, ground-fault, circuit-interrupter type.

P. Roof Curb: Steel with corrosion-protection coating, gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of 14" (350 mm).

Q. Isolation Curb: Rigid upper and lower steel structure with vibration isolation springs having 2" (50 mm) static deflection and vertical and horizontal restraints; with elastomeric waterproof membrane.

2.03 MOTORS

A. Comply with requirements in Division 23 Section 23 05 01 "Motors."

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances.

B. Curb Support: Install roof curb on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure rooftop air conditioners on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.
   1. Gas Piping: Comply with applicable requirements in Division 23 Section "Fuel Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

C. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination in roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to rooftop unit with flexible duct connectors specified in Division 23 Section "Duct Accessories."
   4. Terminate return-air duct through roof structure and insulate space between roof and bottom of unit with 2" (50 mm) thick, acoustic duct liner.

D. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

E. Ground equipment according to Division 26 Section "Grounding and Bonding."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
   1. After installing rooftop air conditioners and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

3.04 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean outside coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Adjust vibration isolators.
13. Inspect operation of barometric dampers.
14. Lubricate bearings on fan.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Start unit according to manufacturer's written instructions.
    a. Start refrigeration system in summer only.
    b. Complete startup sheets and attach copy with Contractor's startup report.
17. Inspect and record performance of interlocks and protective devices; verify sequences.
18. Operate unit for an initial period as recommended or required by manufacturer.
19. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency. Adjust pilot to stable flame.
    a. Measure gas pressure on manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
20. Calibrate thermostats.
21. Adjust and inspect high-temperature limits.
22. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
23. Start refrigeration system and measure and record the following:
    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outside-air, dry-bulb temperature.
    d. Outside-air-coil, discharge-air, dry-bulb temperature.
24. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
25. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outside-air intake volume.
26. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through outside coil or from outside coil to outside-air intake.
27. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
    a. High-limit heat exchanger.

b. Warm-up for morning cycle.
c. Freezestat operation.
d. Economizer to limited outside-air changeover.
e. Alarms.

28. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.05 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. 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 site outside normal occupancy hours for this purpose, without additional cost.

END OF SECTION

SECTION 08 71 00

DOOR HARDWARE

PART I - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF WORK

A. The extent of finish hardware is indicated on the drawings and in schedules.

B. Related Work Specified in Other Sections:

1. Aluminum Doors

2. Adjustable Shelving Supports

3. Drawer Slides

4. Access Panels

C. The Finish Hardware Supplier shall make a survey of all drawings and specifications, and any item of finish hardware not specifically mentioned in the "Finish Hardware Groups" but required for completion of the work shall be provided under this Section without additional cost to the Owner. Such items shall be of type suitable for service required and of equal quality to hardware for similar service.

D. Where the type of hardware specified is not adaptable to the finished size of members requiring hardware, submit an item having a similar operation and quality to the Architect for review.

E. The contractor shall obtain all information required as to details, sizes, thickness, shapes, and bevel of doors and other items requiring hardware from subcontractor furnishing same or from the Architect. Should any openings require hardware not listed in this specification, the contractor shall consult Architect for specifications.

1.3 QUALITY ASSURANCE

A. Supplier

1. A recognized architectural finish hardware supplier, with warehousing facilities, who has been furnishing hardware in the project's vicinity for a period of not less than 2 years, and who is, or who employs an experienced architectural hardware consultant who is available, at reasonable times during the course of the work, for consultation about project's hardware requirements, to Owner, Architect and Contractor.

2. The hardware supplier must be able to show evidence of past experience furnishing and servicing detention hardware.

B. Service

1. The hardware supplier shall have at least one builder's hardware contract man on the staff to service the work to be done. He shall be available on short notice if his services are required. When project is turned over to the Owner, all parts shall be in perfect order.

2. Contractor shall have the factory representative inspect and properly adjust each door closer, lock and exit device at completion of building.

3. At the time of final inspection of building, furnish the Owner with two complete sets of installation instructions, service manuals, maintenance helps, special wrenches or keys required to keep hardware in perfect adjustment. This material shall be in two separate packets - one for the Owner's files and one for the Owner's maintenance staff.

C. Fire-Rated Openings: Provide hardware for fire-rated openings in compliance with NFPA Standard No. 80 and local building code requirements. Provide only hardware which has been tested and listed by UL or FM for types and sizes of doors required and complies with requirements of door and door frame labels.

1. Where emergency exit devices are required on fire-rated doors (with supplementary marking on doors' UL or FM labels indicating "Fire Door to be Equipped with Fire Exit Hardware") provide UL or FM label on exit devices indicating "Fire Exit Hardware".

D. Furnish all finish hardware to comply with the requirements of all laws, codes, ordinances and regulations of the governmental authorities having jurisdiction where such requirements exceed the requirements of the Specifications. Comply with the requirements of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the State of Michigan Construction Code Act Barrier Free Design Law.

E. Hardware to hazardous areas shall comply with the requirements of the regulations for public building accommodations for physically handicapped persons of the governmental authority having jurisdiction.

F. Contract Document Review Log

1. The Contractor's Field Superintendent shall review the requirements of the Contract Documents with each subcontractor's foreman or workman that comes to the job site for the first time. This review shall include a paragraph-by-paragraph joint reading of the appropriate specification section. The Superintendent shall keep a log of this review with the date and initials of both the Superintendent and foreman or workman. This log shall be subject to the Architect's review upon request and failure to comply may be cause for adjustment to the Application for Payment.

1.4 SUBMITTALS

A. Manufacturer's Literature: Furnish to Architect, when required, copies of manufacturer's specifications, maintenance and keying manuals and installation instructions (templates to suit each particular installation), for each item of finish hardware. Include photographs, catalog cuts, marked templates and other data as may be required to show compliance with these specifications.

B. Finish and Color: Submit to the Architect, when requested, prior to the submission of finish hardware, item finish samples. Architect's review and selection shall be for color and texture only of surface finish. Compliance with all other requirements is the exclusive responsibility of the Contractor.

C. Samples: If requested by the Architect, a sample of each hardware item, properly marked and tagged for identification shall be submitted for review.
1. After final review, deliver samples to job site for comparison with hardware delivered for installation. Unblemished samples may be used in the work.

D. Finish Hardware Schedule: Submit to the Architect for review, copies of finish hardware schedule covering complete identification of all items required for the project. Include manufacturer's names and identification of finishes. Include a separate schedule of key and master-key system with final submittal of schedule. Architect's review and approval of schedules shall neither be construed as a complete check nor shall it relieve the supplier of responsibility for errors, deviations or omissions from requirement to provide complete hardware for project.

E. Schedules of hardware shall include a preface sheet showing category only on manufacturers' names of all items to be furnished in the following format:

Category	Specified	Scheduled
Hinges	Manufacturer A	Manufacturer B
Locksets	Manufacturer X	Manufacturer X
Kick Plates	Manufacturer Z	Manufacturer Z

1. Door description shall include single or pair, number, location, hand, active leaf, degree of swing, size, material, frame material and UL listing mark.

2. Hardware description shall include quantity, category, catalog number, fasteners and finish.

3. Supplier's scheduling sequence shall be in duplication of that shown in Hardware Groups. Furnish "Vertical" scheduling format only.

4. Each heading number in supplier's schedule shall include a reference to Architect's Hardware Group Number.

5. The scheduling format and sequence of schedule shall comply with recommendations of the American Society of Architectural Hardware Consultants.

6. Submittal Sequence: Submit schedule at earliest possible date particularly where acceptance of hardware schedule must precede fabrication of other work (e.g., hollow metal frames) which is critical in the project construction schedule. Include with schedule the product data, samples, shop drawings of other work affected by finish hardware, and other information essential to the coordinated review of hardware schedule.

F. Catalog Cuts

1. Provide in booklet form using Supplier's schedule covers as binders four copies of catalog pages of all pieces of hardware listed in Supplier's Schedule that are other than those shown in the Specification.

2. Submit Catalog Booklets concurrently with copies of Hardware Schedule.

3. Review of Hardware Schedule will not begin until Catalog Booklets have been received. At least one copy of Catalog Booklet will be stamped and returned.

G. Templates: Furnish hardware templates to each fabricator of doors, frames and other work to be factory-prepared for the installation of hardware. Upon request, check shop drawings of such other work, to confirm that adequate provisions are made for proper location and installation of hardware.

1.5 PRODUCT HANDLING

A. Package each item of Finish Hardware complete with all screws, bolts, expansion shields, anchors and other fasteners, installation instructions, templates and special adjusting keys or wrenches required for installation. Mark door location and Finish Hardware Schedule Item number on each Package.

B. Delivery of Materials

1. Deliver Hardware to the job site unless otherwise directed. Hardware shall be delivered in their original containers and each item clearly marked so as to agree with Hardware Schedule showing the designated locations. A packing list shall accompany each shipment using item numbers that conform with the approved schedule.

2. The Contractors receiving hardware from this supplier shall sign receipt for same and any subsequent loss and/or missing articles of hardware shall then become the responsibility of the receiving Contractor.

3. Inventory hardware jointly with representatives of hardware supplier and hardware installer until each is satisfied that count is correct.

4. Deliver individually packaged hardware items at the proper times to the proper locations (shop or project site) for installation.

5. Provide secure lock-up for hardware delivered to the project, but not yet installed. Control handling and installation of hardware items which are not immediately

replaceable, so that completion of the work will not be delayed by hardware losses, both before and after installation.

6. Provide typewritten schedule with each shipment in conformity with the approved and filed schedule. The parties receiving hardware from this contractor will receipt for hardware in duplicate.

1.6 GUARANTEE

A. All material furnished under this Contract shall be guaranteed free from defects in manufacture and capable of performing the duties required for which it is designed for a period of one (1) year after final acceptance. Any material failing to comply with the above guarantee shall be replaced with satisfactory material.

B. All door closers shall be guaranteed for five (5) years.

PART II - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are shown with each product category. Furnish each category with the products of only one manufacturer, except where noted otherwise in Hardware Groups. This requirement is mandatory, whether various producers are listed or not.

2.2 MATERIALS SPECIFIED IN SCHEDULE

A. For simplicity and convenience, the Hardware Groups designate hardware items by catalog numbers as manufactured by the following, except as noted for individual items:

1. Locks - Schlage

2. Butts – Ives

3. Closers – Falcon and LCN

4. Stops – Ives and Brookline

5. Kickplates – Ives and Brookline

6. Threshold, Weather Seal, Light Seal – National Guard Products and Reese

2.3 FINISHES

A. Hinges - 626

B. Locksets - 626

C. Closers - Sprayed Aluminum

D. Door Stops - 626

E. Kick Plates - 630

2.4 HARDWARE MOUNTING LOCATIONS

A. Location of Hardware

1. Locate finish hardware in accordance with the following schedule except where door manufacturer's standard required other placement. Consult Architects for any deviation from this schedule. All dimensions are to centerline.

2. Pull Plate - 42"

3. Push Plate - 42"

4. Door Knob - 38"

5. Deadlock - 60" - 56"

6. Bottom Hinge - 10" from floor to bottom of hinge.

7. Top Hinge - 5" from head to top of hinge.

8. Center Hinge - equal distance between top and bottom hinge.

9. Kickplates - 1/4" from door bottom to plate bottom.

2.5 HINGES

A. Hinges shall be Ives of class and size shown in the hardware sets. All hinges, both regular weight and extra heavy, are to be of the oil impregnated ball bearing type. Hinge pins shall be of stainless steel. Hinges are to be of five knuckle construction. All hinges are to have nonremovable pins at exterior doors and security sets.

B. The following hinge manufacturers will be approved as equals, providing they meet the specifications.

1. Stanley
2. H. Soss

2.6 LOCKSETS

A. Locksets shall be Schlage L9000 series, Lever Style 06.

B. The following locksets will be approved as equals, providing they meet the specifications.:

1. Corbin-Russwin ML2000 Newport

2.7 DOOR CLOSERS

A. All door closers shall be of rack and pinion construction with cast iron cases, have key regulated valves, adjustable spring power, adjustable back check and adjustable closing and latching speeds. Concealed closers shall be LCN's 2030 2010 series. Surface closers shall be LCN's 4110- CUSH series, 4110 series, 4010 series, 4020 series, 4110-H-CUSH series as directed in the hardware sets. All door closers shall be of one manufacturer.

B. The following Closer Manufacturer’s will be approved as equals:

1. Falcon

2.8 KICK PLATES

A. Shall be wrought ".050". Use 10" height by door width less 1-1/2" at single and less 1" at pairs of doors. Products from any nationally recognized trim or lock manufacturer are acceptable.

2.9 THRESHOLDS

A. Consult hardware sets for location and type. All thresholds shall be equal in length to full masonry opening and coped when frame is recessed. Cope all thresholds around door frame.

2.10 KEY CABINET

A. Furnish one complete key control wall cabinet Model SMTC-AWC-250-S manufactured by P.O. Moore, Inc., Glen Riddle, Pennsylvania. Finish applied manufacturer in standard neutra-tone gray color. Owner will designate location. Key cabinet shall have hook capacity to hold not less than 10% more keys than is required for the building.

2.11 KEYING

A. Establish a new master key system with construction keying. Individual key sets shall be as directed by the Architect and Owner.

2.12 FINISH HARDWARE (refer to door schedule for numbered hardware sets)

Item:

HINGE 5BB1 4.5 X 4.5	652	IVE	
THRESHOLD	425	AL	NGP
WEATHER SEAL	BY FRAME SUPPLIER	AL	B/O
DOOR SWEEP	C627BLK	AL	NGP
WALL STOP WS33	626	IVE	
KICKPLATE 8400 10” X 34”	630	IVE	
SURFACE CLOSER	SC71 SS	695	FAL
ENTRANCE LOCKSET	LV9453 L06	626	SIM
STOREROOM LOCK	L9080P L06	626	SCH
PASSAGE SET	L9010 L06	626	SCH
OFFICE LOCK	L9050P L06 L583-363	626	SCH

PART III - EXECUTION

3.1 INSTALLATION

A. Mount hardware units at heights indicated in "Recommended Locations for Builders Hardware for Custom Steel Doors and Frames" by the Door and Hardware Institute, except as specifically indicated or required to comply with governing regulations and except as otherwise directed by Architect.

B. Install each hardware item in compliance with the manufacturer's instructions and recommendations. Wherever cutting and fitting is required to install hardware onto or into surfaces which are later to be painted or finished in another way, install each item completely and then remove and store in a secure place during the finished application. After completion of the finishes, re-install each item. Do not install surface-mounted items until finishes have been completed on the substrate.

C. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

D. Drill and countersink units which are not factory-prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.

E. Set thresholds for exterior doors in full bed of butyl-rubber or polyisobutylene mastic sealant.

3.2 ADJUST AND CLEAN

A. Adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Lubricate moving parts with type lubrication recommended by

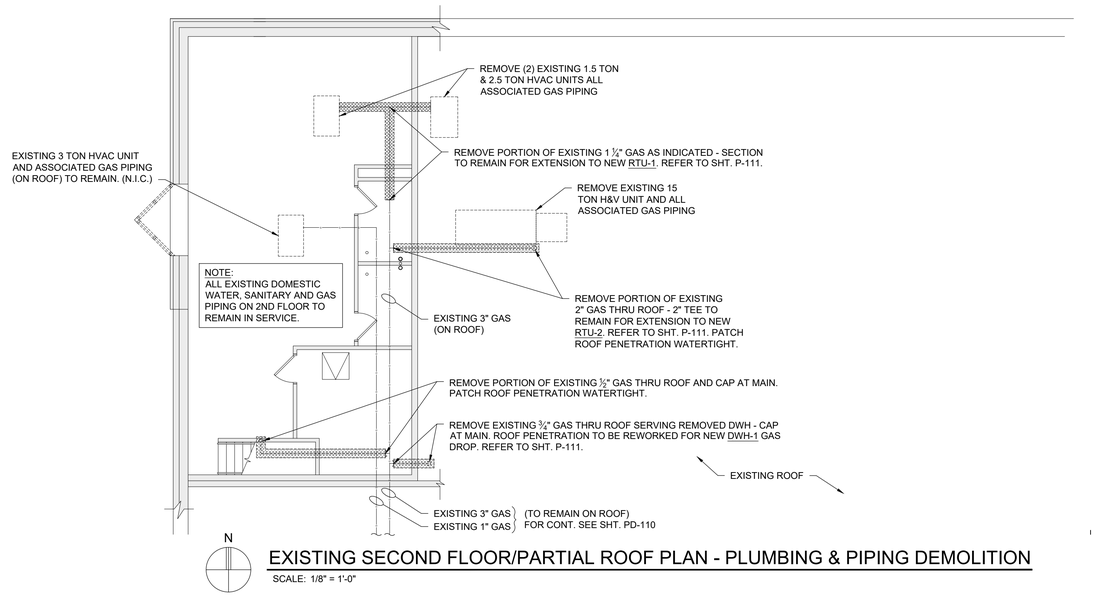
manufacturer (graphite-type if not other recommended). Replace units which cannot be adjusted and lubricated to operate freely and smoothly as intended for the application made.

B. Clean adjacent surfaces soiled by hardware installation.

C. Final Adjustment: Wherever hardware installation is made more than one month prior to acceptance or occupancy of a space or area, return to the work during the week prior to acceptance or occupancy, and make final check and adjustment of all hardware items in such space or area. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust door control devices to compensate for final operation of heating and ventilating equipment.

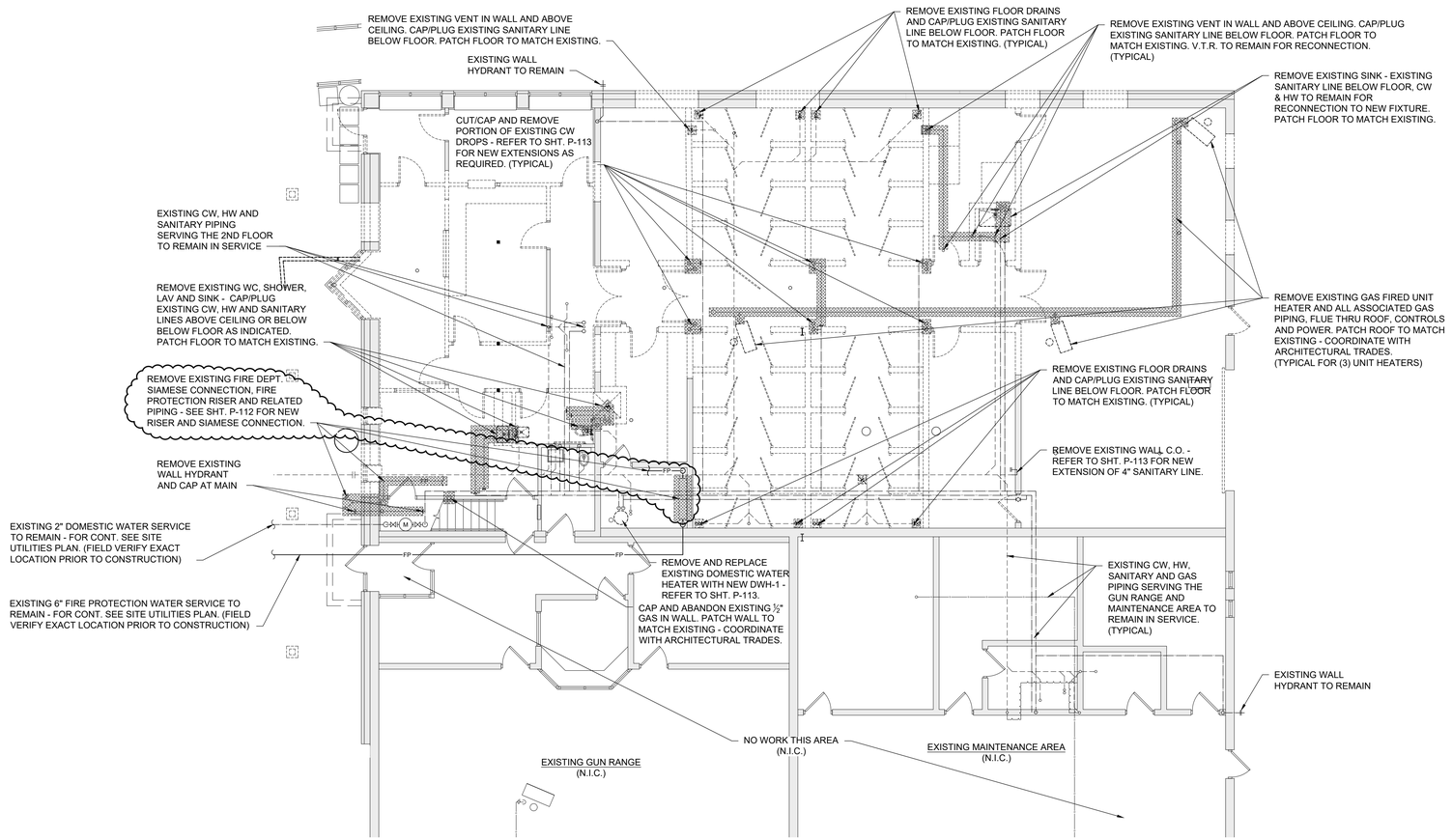
D. Instruct Owner's Personnel in proper adjustment and maintenance of hardware and hardware finishes, during the final adjustment of hardware.

END OF SECTION



EXISTING SECOND FLOOR/PARTIAL ROOF PLAN - PLUMBING & PIPING DEMOLITION

SCALE: 1/8" = 1'-0"



EXISTING FIRST FLOOR PLAN - PLUMBING & PIPING DEMOLITION

SCALE: 1/8" = 1'-0"

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Project:
City of Taylor
Animal Shelter
Remodel & Expansion

25555 Northline Rd.
Taylor, MI 48180

Seal:

STATE OF MICHIGAN
CYRIL MIRANDA
ENGINEER
No. 31006
PROFESSIONAL ENGINEER

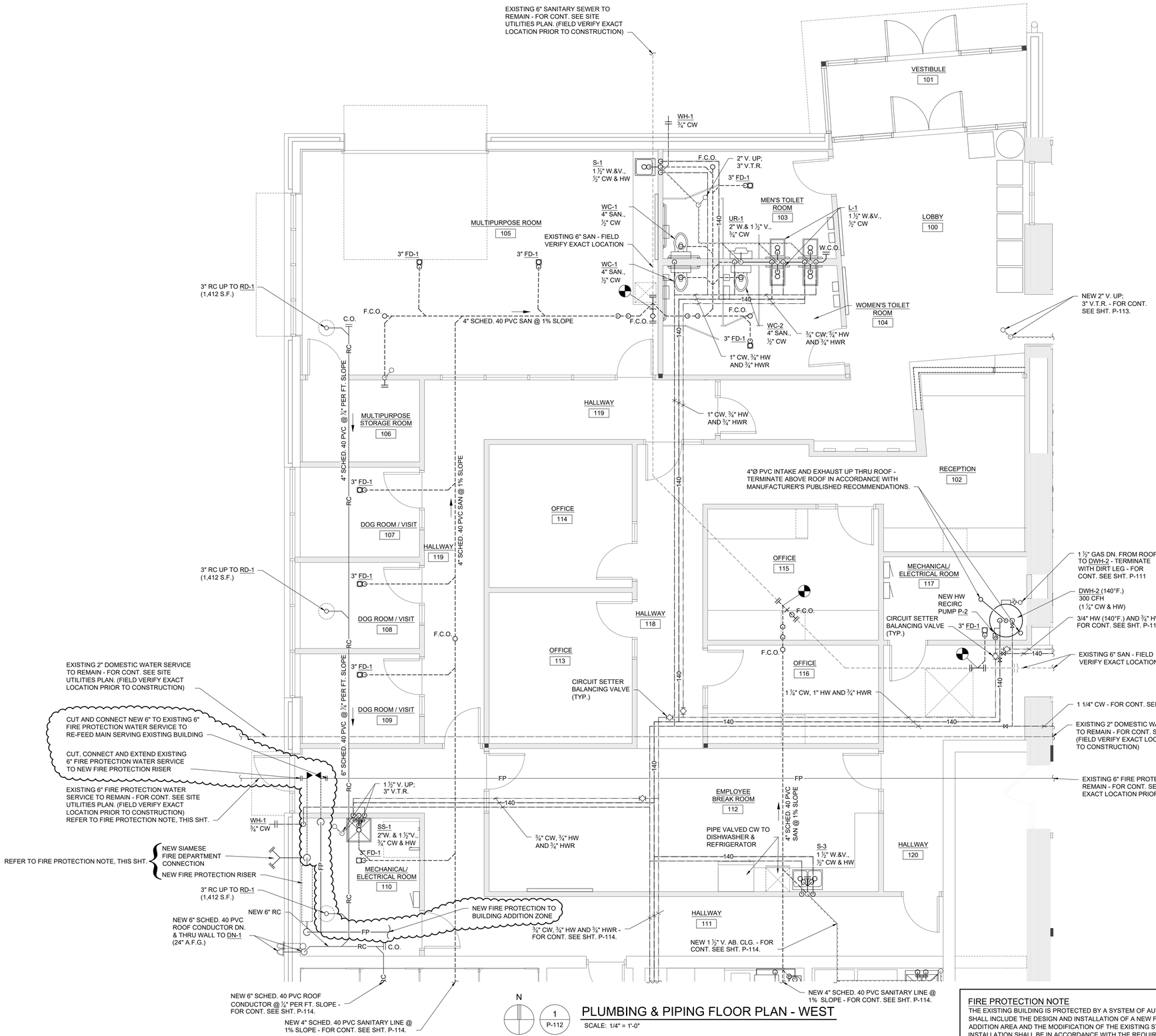
Date	Issued For
12/21/2023	OWNER REVIEW
01/17/2024	PERMIT SET
04/19/2024	ADDENDUM #3

Drawn: KWG
Checked: CM
Approved: WAD

Sheet Title:
PLUMBING & PIPING DEMOLITION FLOOR PLANS

Project Number: 22712.A

Sheet Number: PD-110



PLUMBING & PIPING FLOOR PLAN - WEST

SCALE: 1/4" = 1'-0"

FIRE PROTECTION NOTE

THE EXISTING BUILDING IS PROTECTED BY A SYSTEM OF AUTOMATIC SPRINKLERS. THE SCOPE OF THIS PROJECT SHALL INCLUDE THE DESIGN AND INSTALLATION OF A NEW FIRE PROTECTION SYSTEM TO COVER THE BUILDING ADDITION AREA AND THE MODIFICATION OF THE EXISTING SYSTEM TO SUIT THE NEW LAYOUT. DESIGN AND INSTALLATION SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF N.F.P.A. - 13 FOR AN ORDINARY HAZARD, GROUP I CLASSIFICATION. THE FIRE PROTECTION CONTRACTOR SHALL BE RESPONSIBLE FOR THE ENTIRE SYSTEM DESIGN, APPROVAL AND INSTALLATION AND SHALL SUBMIT TO THE ARCHITECT/ENGINEER FOR RECORD DESIGN DRAWINGS AND HYDRAULIC CALCULATIONS BEARING THE APPROVAL OF THE LOCAL FIRE AUTHORITY.

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STATE OF MICHIGAN — CYRIL MIRANDA — ENGINEER — No. 31006 — PROFESSIONAL ENGINEER

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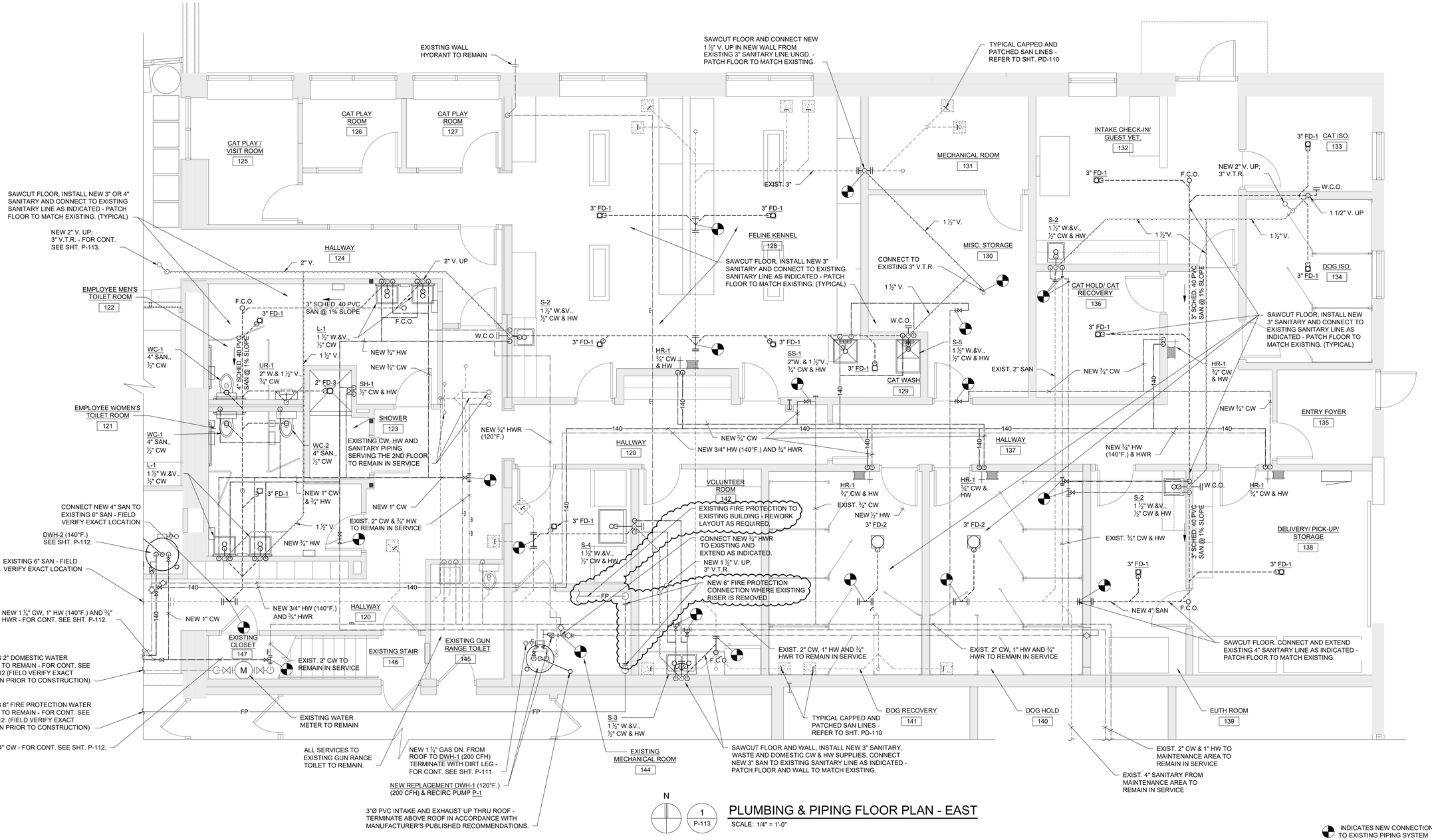
Sheet Number: P-112



PLUMBING & PIPING FLOOR PLAN - EAST

SCALE: 1/4" = 1'-0"

INDICATES NEW CONNECTION TO EXISTING PIPING SYSTEM

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Project Number: 22712.A

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