SECTION 221316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Hubless, cast-iron soil pipe and fittings.
2. Copper tube and fittings.
3. ABS pipe and fittings.
4. PVC pipe and fittings
5. CPVC pipe and fittings.
6. Specialty pipe fittings.
7. Encasement for underground metal piping.

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B. Related Requirements:

1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.
2. Section 221329 "Sanitary Sewerage Pumps" for effluent and sewage pumps.
3. Section 226600 "Chemical-Waste Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.

1.03 ACTION SUBMITTALS

A. Submittals shall be formatted per Section 220000 “General Plumbing Requirements”

B. Product Data: For each type of product.

C. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

D. Shop Drawings: For hubless, single-stack drainage system include plans, elevations, sections, and details.

1.04 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.05 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Architect, Construction Manager and Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Architect's, Construction Manager's and Owner's written permission.

1.06 WARRANTY

A. Listed manufacturers to provide labelling and warranty of their respective products.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.02 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.03 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

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

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings: ASTM A888 or CISPI 301.

C. CISPI, Hubless-Piping Couplings:

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

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:

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

a. ANACO-Husky.
b. Charlotte Pipe and Foundry Company.
c. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C1277 and ASTM C1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.04 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B88, Type L and Type M, water tube, drawn temper.

D. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

F. Solder: ASTM B32, lead free with ASTM B813, water-flushable flux.

2.05 ABS PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall ABS Pipe: ASTM D2661, Schedule 40.

C. ABS Socket Fittings: ASTM D2661, made to ASTM D3311, drain, waste, and vent patterns.

D. Solvent Cement: ASTM D2235.

1. Solvent cement shall have a VOC content of 325 g/L or less.
2. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F656.

1. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. Solvent Cement: ASTM D2564.

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1. Solvent cement shall have a VOC content of 510 g/L or less.

2.07 CPVC PIPE AND FITTINGS

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A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. CPVC PIPE: ASTM F441, Schedule 40.

C. CPVC Socket Fittings: ASTM D-1784, drain, waste, and vent patterns.

D. Solvent Cement: ASTM D-2564.

1. Solvent cement shall have a VOC content of 325 g/L or less.
2. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.08 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2. Shielded, Nonpressure Transition Couplings:

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

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company, LLC; a division of MCP Industries.

b. Standard: ASTM C1460.
c. Description:Elasto

d. R7ic or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
e. End Connections: Same size as and compatible with pipes to be joined.

2.09 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch or high-density, cross-laminated polyethylene film of 0.004-inchminimum thickness.

C. Form: Sheet or tube.

D. Color: Natural.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Provided seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. All cleanouts shall be installed where readily accessible. The contractor shall coordinate all cleanout locations with equipment, cabinets, etc. and architect prior to any installation.

L. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

    a. Reducing size of waste piping in direction of flow is prohibited.

M. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

N. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 or 2percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

O. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A674 or AWWA C105/A 21.5.

P. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

Q. Install aboveground ABS piping according to ASTM D2661.

R. Install aboveground PVC piping according to ASTM D2665.

S. Install underground ABS and PVC piping according to ASTM D2321.

T. Install engineered soil and waste and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

U. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

1. Install encasement on piping according to ASTM A674 or AWWA C105/A 21.5.

V. Install force mains at elevations indicated.

W. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.

    a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

    a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
    b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

3. Install drains in sanitary waste gravity-flow piping.

    a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

X. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Y. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Z. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

AA. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.03 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
    c. Do not use pipe sections that have cracked or open welds.

C. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

D. Join copper tube and fittings with soldered joints according to ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

E. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

F. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

G. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
3. PVC Piping: Join according to ASTM D2855 and ASTM D2665 appendixes.

3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Unshielded or Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges, flange kits or nipples.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.05 VALVE INSTALLATION

A. Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment." and Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel or fiberglass pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install supports for vertical steel piping every 15 feet.

I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 84 inches with 3/8-inch rod.
2. NPS 3: 96 inches with 1/2-inch rod.
3. NPS 4: 108 inches with 1/2-inch rod.
4. NPS 6: 10 feet with 5/8-inch rod.

J. Install supports for vertical stainless-steel piping every 10 feet.

K. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

L. Install supports for vertical copper tubing every 10 feet.

M. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 48 inches with 7/8-inch rod.

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N. Install supports for vertical ABS and PVC piping every 48 inches.

O. Install hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 36 inches with 3/8-inch rod.
2. NPS 3: 36 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 36 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 36 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 36 inches with 7/8-inch rod.

P. Install supports for vertical CPVC piping every 36 inches.

Q. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
6. Comply with requirements for backwater valves cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
7. Equipment: Connect waste piping as indicated.

    a. Provide shutoff valve if indicated and union for each connection.
    b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.08 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.09 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

    a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
    b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
    c. Air pressure must remain constant without introducing additional air throughout period of inspection.
    d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Cover all floor drains and floor sinks during constructions to prevent debris from entering pipe and protect grates from damages.

D. Place plugs in ends of uncompleted piping at end of day and when work stops.

E. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

F. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings and hubless, single-stack aerator fittings; CISPI or heavy-duty hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.
5. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
6. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
7. CPVC socket fittings, and solvent-cemented joints.
8. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

C. Aboveground, soil and waste piping NPS 5 and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings and hubless, single-stack aerator fittings; CISPI or heavy-duty hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. CPVC socket fittings, and solvent-cemented joints
6. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI or heavy-duty hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.

a. Option for Vent Piping, NPS 2-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.

5. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
6. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
7. CPVC socket fittings, and solvent-cemented joints
8. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

E. Aboveground, vent piping NPS 5 and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI or heavy-duty hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. CPVC socket fittings, and solvent-cemented joints
6. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

F. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty cast-iron hubless-piping couplings; and coupled joints.
2. Solid wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. CPVC socket fittings, and solvent-cemented joints
5. Dissimilar Pipe Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

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G. Underground, soil and waste piping NPS 5 and larger shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI or heavy-duty cast-iron hubless-piping couplings; coupled joints.
2. Solid-wall PVC pipe; PVC socket fittings; and solvent-cemented joints.
3. CPVC socket fittings, and solvent-cemented joints
4. Dissimilar Pipe Material Couplings: Unshielded or Shielded, nonpressure transition couplings.

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END OF SECTION 221316

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Condensate drain piping
   2. Refrigerant piping

B. Related Sections:
   1. Section 230713 "Duct Insulation."

1.03 ACTION SUBMITTALS

A. Submittals shall be formatted per Section 230000 “General Mechanical Requirements”.

B. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory and field applied, if any). Clearly mark the materials being provided and its intended use of each product

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports if requested by the Owner's Representative.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

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B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Insulation shall be delivered to the job site in original, unopened manufacturer's containers.

C. Insulation shall be stored in a dry location and kept dry throughout construction.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Systems."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.08 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Products shall not contain CFC, asbestos, lead, mercury, or mercury compounds.

B. Insulation shall meet fire and smoke hazard ratings as tested under procedure ASTM E-84, NFPA 255, and UL 723 and shall not exceed flame spread rating of 25 and maximum smoke developed rating of 50.

C. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Johns Manville's Micro-Lok *HP* all-service (ASJ) vapor-retarder jacket with a self-sealing longitudinal closure lap (SSL) and butt strips.
      b. Owens Corning; ASJ Fiberglas Pipe Insulation.
   2. Preformed mineral fiber pipe insulation with factory applied all-service vapor-retarder jacket (ASJ) jacket with a self-sealing longitudinal closure lap (SSL) and butt strips or approved alternate to seal butt joints. Preformed mineral fiber pipe insulation shall conform to ASTM C547. The ASJ facing shall conform to ASTM C1136 Type I.
   3. Preformed mineral fiber pipe insulation with factory applied all-service vapor-retarder jacket (ASJ) jacket shall have a flame spread rating not greater than 25 and a smoke developed rating not greater than 50 when tested as in accordance with ASTM E84, UL 723.
   4. Thermal conductivity (k-value): 0.23 Btu-in/hr-ft^2-°F at 75°F
   5. Preformed mineral fiber pipe insulation shall have a water vapor sorption of less than 5% by weight as tested in accordance ASTM C 547.
   6. All service jacket (ASJ) shall have a water vapor permeance of 0.02 perms or less as tested in accordance to ASTM E96, procedure "A".
   7. When a vapor mastic is required, a water vapor permeance of 0.02 per ASTM E-96 Procedure B must be achieved.
   8. All accessory materials such as field installed jackets, mastics, coatings, tapes, fasteners shall be recommended by each component manufacturer for the specified application or as listed in the NAIMA Guide to Insulating Chilled Water Systems with Mineral Fiber Pipe Insulation.
   9. Fittings, valves, tees, etc. shall be insulated with fiberglass insulation inserts covered with white PVC insulated fitting covers.

D. Flexible Elastomeric Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Armacell LLC Armaflex.
      b. Aeroflex USA, Inc. Aerocel.
      c. K-Flex USA Insul-sheet.
   2. Closed-cell. Comply with ASTM C 534, Type I for tubular materials.
   3. Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   4. Pipe insulation shall be fabricated according to the requirements of ASTM C1639 "Standard Specification for Fabrication of Cellular Glass Pipe and Tubing Insulation".
   5. Thermal Conductivity: 0.25 Btu-in/hr-ft^2-°F at 75°F.

2.02 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Adhesives shall contain no flammable solvents if that option is available.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA Inc.; Aeroseal.
      b. Armacell LCC; 520 BLV Adhesive.
      c. Foster Products Corporation, H. B. Fuller Company; 85-75.
      d. RBX Corporation; Rubatex Contact Adhesive.
   2. For indoor applications use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Design Polymerics DP 2590-CA
      b. ITW TACC, Division of Illinois Tool Works; SP80, T1080
      c. Marathon Industries, Inc.
   2. For indoor applications use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Design Polymerics DD2590-CA.
      b. ITW TACC, Division of Illinois Tool Works; SP80, T1080
      c. Marathon Industries, Inc.
   2. For indoor applications use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Dow Chemical Company (The); 739, Dow Silicone.
      b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
      c. P.I.C. Plastics, Inc.; Welding Adhesive.
      d. Speedline Corporation; Speedline Vinyl Adhesive.
   2. For indoor applications use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.03 MASTICS

A. Materials shall water based and be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 40 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-35.
      b. Design Polymerics 3040 with zero VOC's.
      c. Foster Products Corporation, H. B. Fuller Company; 30-90.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-10.
   b. Foster Products Corporation, H. B. Fuller Company; 35-00.
   c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.04 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45.
   c. Marathon Industries, Inc.; 405.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-76-8.
   b. Foster Products Corporation, H. B. Fuller Company; 95-44.
   c. Marathon Industries, Inc.; 405.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-76.
   b. Or equal.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications and use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 FACTORY-APPLIED JACKETS

A. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.06 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. PVC Jacket Color:
a. Exposed Refrigerant Piping:
1) Color by Architect
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Moisture Barrier Jacket:
1. Manufacturer: Pittsburg Corning PITTWRAP or approved equal.
2. 125 mil thick heat-seal multi-ply laminate consisting of three layers of a polymer-modified bituminous compound separated by glass reinforcement and aluminum foil.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.
c. RPR Products, Inc.; Insul-Mate.
2. Factory cut and rolled to size.
3. Finish and thickness are indicated in field-applied jacket schedules.

4. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and 40 pound kraft paper.
6. Factory-Fabricated Fitting Covers:
   a. Same material, finish, and thickness as jacket.
   b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
   c. Tee covers.
   d. Flange and union covers.
   e. End caps.
   f. Beveled collars.
   g. Valve covers.
   h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.07 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Compac Corporation; 104 and 105.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
   2. Width: 3 inches.
   3. Thickness: 11.5 mils
   4. Adhesion: 90 ounces force/inch in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
      b. Compac Corp.; 130.
      c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
      d. Venture Tape; 1506 CW NS.
   2. Width: 2 inches.
   3. Thickness: 6 mils.
   4. Adhesion: 64 ounces force/inch in width.
   5. Elongation: 500 percent.
   6. Tensile Strength: 18 lbf/inch in width.

2.08 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch thick, 1/2 inch 3/4 inch wide with closed seal.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following]:

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, Monel.
1. Manufacturers: Subject to compliance with requirements, provide product by:
a. C & F Wire.
b. Childers Products.
c. PABCO Metals Corporation.
d. RPR Products, Inc.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify all inspection and acceptance testing of the piping as required by the specification has been completed and that the piping is ready for installation of insulation.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.
4. Verify there is adequate clearance to install the pipe insulation in accordance with the operation performance parameters of the specification, such as access to controls, valves and for maintenance and repair.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Insulation shall not be installed until the following have been completed and documentation has been submitted to Owner for approval and record:
1. Cleaning and flushing
2. Pressure testing

B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during application and finishing.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.

K. Install rigid pre-insulated pipe supports to protect from compression of insulation material due to point loads.

L. Provide aluminum sleeves at all pipe support joints, between hanger support and exterior layer of insulating systems, to protect from compression of insulation material due to point loads.

M. Install insulation on piping accessories requiring future access and service with factory fabricated insulation covers that are easily removed and reapplied.

N. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

O. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

P. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1.5 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

Q. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

R. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

S. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

T. Existing pipe insulation damaged or affected by the work of this contract shall be repaired to comply with these specifications except that materials and thicknesses may match existing unless otherwise directed by the Owner's Representative.

U. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations:
1. Terminate insulation with sleeve seal at wall penetration.
2. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations: Install insulation continuously through walls and partitions.

E. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

B. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.06 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
5. On chilled water systems, the butt end of every fourth pipe insulation section, and the ends or raw edges of insulation terminations at equipment connections, fittings and fire stop systems shall be sealed with vapor retarder mastic per NAIMA Guide to Insulation Chilled Water Systems, 2015.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.07 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.08 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install as follows:
   1. With 1-inch overlap at longitudinal seams and end joints; for horizontal applications.
   2. Seal with manufacturer's recommended adhesive.
   3. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install as follows:
   1. With 2-inch overlap at longitudinal seams and end joints.
   2. Overlap longitudinal seams arranged to shed water.
   3. Seal end joints with weatherproof sealant recommended by insulation manufacturer.
   4. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.09 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant piping:
   1. NPS 1-1/2 inch and smaller: Mineral Fiber, pre-formed pipe insulation, 2 inches thick or flexible elastomeric, 2 inches thick.

B. Condensate Drain Piping:
   1. All Pipe Sizes: Flexible elastomeric, 1/2 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed: None.

C. Piping, Exposed: PVC, 30 mils thick for all indoor applications.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed: None.

C. Piping, Exposed: Aluminum, Stucco Embossed, 0.024 inch thick.

END OF SECTION

4

SECTION 23 09 00
BUILDING AUTOMATION CONTROL SYSTEM

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Furnish a totally native BACnet-based system, based on a distributed control system in accordance with this specification. All building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2001, BACnet. In other words, all controllers, including unitary controllers, shall be native BACnet devices. The control system shall be Delta Controls BACnet-IP.

B. The controls system shall be manufactured by Delta Controls Inc. and installed by an authorized Delta Controls Inc. installer, no exceptions or substitutions. Please see authorized Delta Controls, Inc. Installers in section 1.4 (a).

C. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

D. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.

E. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

F. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

G. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

H. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

I. Provide / coordinate the required Network Switch/POE required for all the controllers between Owner, IT Contractor and Controls Contractor before provided bid price.

J. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning

K. Provide a comprehensive operator and technician training program as described herein.

L. Provide as-built documentation, software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

M. Provide new sensors, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.2 SYSTEM DESCRIPTION

A. Contractor shall design and provide a complete and operational DDC control system that meets the intent of the sequence of operations. It shall connect to Owner's existing Delta

Controls, Inc. building control system.

B. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2010, BACnet. This system is to control installed mechanical equipment using BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

A. All application controllers for shall communicate on a peer-to-peer basis. Application controllers shall be mounted next to controlled equipment and communicate with building controller via BACnet-IP.

B. All controllers shall be programmed with graphical logic programming tools. Line code programmed controllers are not allowed.

C. Room sensors shall be provided with digital readout that allows the user to view room temperature, adjust the room setpoint within preset limits and set desired override time. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow technician to balance VAV zones and access any parameter in zone controller.

1.3 APPROVED MANUFACTURERS

A. Delta Controls, Inc. or approved equal.

B. Only BTL approved equipment furnished by the above listed manufacturer will be acceptable. Products not BTL approved will be rejected. Any manufacturer other than the listed above are not acceptable, no exceptions or substitutions.

1.4 APPROVED VENDORS

A. The following contractors based on engineer/campus approval of vendors assigned programmer:
   1. Automated Control Services
   2. Envise
   3. Mesa Energy Services
   4. Or approved equal by the Engineer and Owner.

B. Only pre-qualified contractors approved by the owner will be acceptable. Any installer other than the listed above are not acceptable, no exceptions.

1.5 QUALITY ASSURANCE

B. Responsibility: The supplier of the EMCS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished.

C. Component Testing: Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. Each and every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.

D. Tools, Testing and Calibration Equipment: The EMCS supplier shall provide all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the system.

E. The systems control manufacturer shall have been an established manufacturer of BACnet protocol systems for a minimum of fifteen years.

F. Control system shall be engineered, programmed and supported completely by

representative's local office that must be within 70 miles of project site. The control contractor shall be independent; and shall not be a subsidiary or affiliated with a Mechanical Contractor.

G. Prior to receiving approval to proceed on this project the contractor must provide and demonstrate the following:
   1. Ten (10) customer references in San Diego and Orange County with installed native BACnet systems as specified for this project.
   2. Five (5) large references in the Southwestern United States with installed native BACnet systems as specified for this project.
   3. Reference Information must include the following:
      a. Customer name
      b. Address
      c. Contact name
      d. Contact phone number
      e. System description
      f. Statement of BACnet compliance

1.6 PROJECT MANAGEMENT

A. Have present at the project site, a project manager who shall, as a part of their duties, be responsible for the following activities:
   1. Coordination between the Subcontractor and all other trades, Owner, Local Authorities, and design team.
   2. Coordination of all activities between his subcontractors.
   3. Attendance at subcontractor/general contractor meetings.
   4. Scheduling of work progress, manpower loading, material delivery, equipment installation and checkout.
   5. Coordination of all drawings and submittals between consultants, engineers, other sub-trades and his subcontractors.
   6. Supervision of field technicians and interface with other trades.

1.7 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
   1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
   2. ANSI/ASHRAE Standard 135-2010, BACnet.
   3. Uniform Building Code (UBC), including local amendments.
   4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
   5. National Electrical Code (NEC).
   6. FCC Part 15, Subpart J, Class A.
   7. EMC Directive 89/336/EEC (European CE Mark)
   8. City, county, state, and federal regulations and codes in effect as of contract date.

B. Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

1.8 SUBMITTALS

A. Drawings:
   1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
   2. Drawings shall be submitted in the following standard sizes: 11” x 17” (ANSI B).
   3. Eight complete sets (copies) of submittal drawings shall be provided.
   4. Drawings shall be available on CD-ROM.

B. System Documentation: Include the following in submittal package:
   1. System configuration diagrams in simplified block format
   2. All input/output object listings and an alarm point summary listing.
   3. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
   4. Complete bill of materials, valve schedule and damper schedule.
   5. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
   6. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
   7. For all system elements—building controller(s), application controllers, routers, and repeaters — provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2010.
   8. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management: The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents and shall indicate timing and dates for system installation, debugging, and commissioning.

1.9 WARRANTY

A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from Substantial completion.

B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.

C. This warranty shall apply equally to both hardware and software.

1.10 RELATED WORK IN OTHER SECTIONS

A. Refer to Division 0 and Division 1 for related contractual requirements

PART 2 – PRODUCTS

2.1 ALL CONTROLLERS SHALL BE BACnet/IP:

A. All BACnet/IP Controllers shall use the following communication specifications and achieve performance as specified herein:
   1. All controllers shall be able to communicate peer-to-peer without the need for a

Network Control Unit (NCU)

a. Any controller connected on the same communication cabling. Slave controllers are not acceptable.
b. Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

B. Internet of Things (IoT)
1. Industry standard IP switches, routers and other network devices as required shall be used at the network level as a manager(s)
2. The resulting network will be a 'Flat' topology with all devices (controllers, workstations, etc.) connect at the same physical network.

A. BACnet Conformance
1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Files Functional Group
   b. Reinitialize Functional Group
   c. Device Communications Functional Group
2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

B. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure independent control algorithms and all flow readings shall be in CFM (LPS if metric).

C. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen

and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator workstation section. All programming tools shall be provided as part of system.

D. Application controller shall include support for intelligent room sensor (see Section 2.07.G.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.

E. On board flow sensor shall be microprocessor driven and pre-calibrated at the factory. Pre-calibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in terminal box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration.

2.2 Remote Access and Cyber Security Best Practices

A. Remote Access

1. The BAS contractor shall comply with owner IT infrastructure security policies for remote access. The owner IT team shall provide VPN, firewalls, etc. as needed for secure remote access.

2. A VPN and firewall must be used for secure remote access.

B. Cyber Security Best Practices

1. Unless predetermined by the owner IT team the BAS network shall be separate from the owners IT infrastructure besides a single point connection for remote access (owner provided internet access). All ethernet switches and communication backbone required for a fully operational BAS shall be provided by the BAS contractor.

2. Refer to “Communication Backbone” section of this specification for further details on segmenting the network (VLANs, subnets) and when managed switches (with port security, network user interface, etc.) are required based on building size / type.

3. Do not use factory provided usernames and passwords. Update passwords and usernames regularly for strong system security.

4. Update software and firmware regularly.

5. Adhere to controls manufacturer hardening guidelines where applicable.

2.3 Computer Hardware

A. Provide the following computer hardware for this project:

1. Uninterruptable Power Supplies

B. Uninterruptable Power Supplies

1. Provide the OWS, Server, and each network/building controller with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

2. Acceptable Manufacturer is APC.

2.2 SENSORS AND MISCELLANEOUS DEVICES

A. Temperature Sensors:
1. All temperature sensors to be solid state electronic, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake and in a location that is in the shade most of the day.

B. Averaging Duct Type Temperature Sensors:
1. BAPI or Engineer approved equal.
   a. Operating Temperature: -40 to 240°F
   b. Sensing Element: NTC 10K (Type II) Thermistor
   c. Accuracy: +/- 1°F.
2. Averaging duct temperature sensors with multiple sensing points shall be installed in ductwork that has a dimension greater than 48 inches and where air temperature stratification exists. Install complete with end cap, compression fittings, gaskets, mounting flange, and required accessories. Provide capillary supports at the sides of the duct to support the sensing string.

C. Duct Type Temperature Sensors:
1. BAPI or Engineer approved equal.
   a. Operating Temperature: -40 to 240°F
   b. Sensing Element: NTC 10K (Type II) Thermistor
   c. Accuracy at Calibration Temperature: +/- 1°F.
2. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces, in close proximity to coils so as to display inaccurate temperatures, or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element.
3. Duct mount sensors shall mount in an electronic box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (Seal-lite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.

4. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304/316 stainless steel.
5. Duct sensors shall not be mounted within 36 inches of heating and cooling coils.
6. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.

D. Outdoor Air Temperature and Humidity:
1. Vaisala HUMICAP Outdoor Humidity and Temperature Transmitter HMD60YO or Engineer approved equal.
   a. Humidity Operating Range: 0-100% RH
   b. Humidity Output Signal: 4 to 20mA, 0 to 100% linear, proportional
   c. Humidity Accuracy: +/- 2.0% RH, 0-90% RH.
   d. Humidity Sensing Element: HUMICAP 180
   e. Temperature Range: -40 to 140°F
   f. Temperature Output Signal: 4 to 20mA, 0 to 100% linear, proportional
   g. Temperature Accuracy: +/- 0.36°F
   h. Sensing Element: 1K-ohm Platinum RTD 1/3 Class B IEC 751
2. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. They shall also be provided with a solar radiation shield.

E. Intelligent Room Sensor with LCD Readout:
1. Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit, and shall allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
2. The Intelligent Room Sensor shall simultaneously display room setpoint, room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day, room humidity and outdoor humidity. Unit must have the capability to show temperatures in Fahrenheit or Centigrade.
3. Override time may be set and viewed in half-hour increments. Override time count down shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word “OFF” in unoccupied mode unless a function button is pressed.
4. See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list.
5. Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to terminal controller, terminal box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

F. Wall Sensor:
1. Standard wall sensor shall use solid-state sensor identical to intelligent room sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function, warmer/cooler lever for set point adjustment and port for plug-in of

Field Service Tool for field adjustments. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to Field Service Tool through wall sensor port.

G. CO2 Sensors
   1. Provide indoor air quality sensors to monitor Carbon Dioxide (CO2) levels. Manufacturer shall be Vaisala Model GMW116 or Engineer approved equal.
   2. Sensors shall be of microprocessor-based photoacoustic type with heated stannic dioxide semiconductor, and have no more than 1% drift during the first year of operation.
   3. Wall mounted sensors shall be provided with white plastic cover without LED indicators.
   4. Duct mounted sensors shall be provided with LED indicators in a dust proof plastic housing with transparent cover.
   5. The sensor shall meet the following requirements:
      a. Operating voltage: 24 VAC +/- 20%
      b. Frequency: 50/60 Hz
      c. Power Consumption: max 6 VA
      d. CO2 measuring range: 0 – 2000 ppm
      e. Tolerance: +/- 100 ppm
      f. Output: 0 – 10 VAC
      g. Calibration: none required

H. Air Differential Pressure Transmitters
   1. Air differential pressure sensors shall be Setra Model 267 with LCD display transmitters or Engineer approved equal.
   2. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
   3. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
   4. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
   5. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
      a. Span: Refer to Points List
      b. Accuracy: ±0.5% of full scale
      c. Non-Repeatability: ±0.05%
      d. Non-Linearity: ±0.35%
      e. Response: Less than one second for full span input.
      f. Temperature Stability: Less than 0.02%FS/°F change
      g. Output: 4 to 20 mA

I. Red/Green Indicator Lights
   1. One red indicator light and one green indicator light shall be mounted in a single gang recessed box.
      a. Round, incandescent, flush indicator light.

b. Nylon body with polycarbonate lens and stainless-steel bezel.
c. 24 VDC, 6” wire leads
d. 1/2” mounting diameter

J. Current Transformers
1. The current transformers shall be provided to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.
2. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
3. The current transformers shall meet the following specifications.
a. Frequency Limits: 50 to 400 Hz.
b. Insulation: 0.6 KV Class, 10 KV BIL.
c. Accuracy: ± 1 % at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
d. Provide a disconnect switch for each current transformer.

K. Current Switches
1. Current sensing switch shall be self-powered with solid-state circuitry and a dry contact output.
2. Current sensing switches shall consist of a solid-state current sensing circuit, adjustable trip point, solid state switch, SPDT relay and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over current up to twice its trip into range.

L. Power Meters
1. TO Be VERIS E50H2 or approved equal.
2. The power meter shall be fully electronic with multi-line backlit LCD display showing measured parameters as well as alarm functions and pulse output.
3. The power meter shall perform the following measurements:
a. Accumulated Real Energy (kWh) for each phase and total of all phases
b. Accumulated Reactive Energy (kVARh) and Apparent Energy (kVAh) totals for all phases
c. Net Present Demand for Real (kW), Reactive (kVAR) and Apparent (kVA) Power over a user-specified interval (block or sliding window)
d. Maximum (Peak) Real (kW), Reactive (kVAR) and Apparent (kVA) Demand Intervals
e. Instantaneous Real (kW), Reactive (kVAR) and Apparent Power (kVA), by phase and in total
f. Current (amps) for each phase and average of all phases
g. Phase-to-phase voltage for each phase and average of all phase pairs
h. Phase-to-neutral voltage for each phase pair and average of all phases
i. Power factor for each phase and average of all phases
j. AC frequency
4. The power meter shall communicate using the BACnet MS/TP protocol at speeds from 9600 to 115,200 baud (no parity). The meter shall provide a BACnet Device object, a set of writable Analog_Value objects for remote configuration, a set of Analog_Input objects to provide access to scaled 32-bit measurement values and their unit types, and a set of Binary_Input objects for indicating individual alarm conditions.
5. The meter shall be UL/CUL listed to the latest applicable safety standards.

6. Power meter models must be available to directly accept voltage input over the range of 90 to 600 VAC (50 or 60Hz).
7. The power meter shall accept either 0 to 0.333VAC or 0 to 1VAC input from up to three current transducers to 32000 amps.
8. The measured energy consumption shall be retained in non-volatile memory for the life of the product warranty.
9. The power meter shall have demand measurement programmable for up to 6 sub-intervals of 10 seconds to 546 minutes duration.
10. Meter shall be optionally available in an outdoor NEMA 4X enclosure.
11. The power meter shall operate from -30C to +70C.
12. The power meter shall have dimensions not exceeding 4.2” x 3.6” x 2.3”.
13. The power meter shall meet both ANSI C12.20 .5% and IEC 62053-22 Class .5S real power and energy accuracy specifications.
14. The power meter shall meet IEC 62053-22 Class 2 reactive power and energy accuracy specifications.
15. The power meter shall be configurable for operation on Single Phase (AN or AB), Split Phase (ABN), Delta (ABC), and Wye (ABCN) systems.
16. The power meter shall have automatic phase reversal compensation such that it is insensitive to the CT’s load orientation.
17. The power meter shall have separate control power inputs such that is may be powered from a different service than it measures.
18. The power meter shall have Phase Loss Alarm contacts with a user configurable phase loss threshold.
19. The power meter shall have a user-configurable Pulse Contact input to support measurement of other related energy (Gas, Water, Steam, etc.) via BACnet using a simple pulse-output transducer.
20. The power meter shall be configurable for use with Potential Transformers to 32000 volts.
21. The power meter shall support warnings for low power factor (phase current or voltage miss-wired), current over range, voltage over range, and frequency out of range.
22. The product shall have a 5-year warranty.

M. Power Supplies and Line Filtering
1. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
   a. DC power supply output shall match output current and voltage requirements. Unit shall be full wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
   b. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
   c. Line voltage units shall be UL recognized and CSA listed.
2. Power Line Filtering.

a. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
b. Dielectric strength of 1000 V minimum
c. Response time of 10 nanoseconds or less
d. Transverse mode noise attenuation of 65 dB or greater
e. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

N. LCD Operator Terminal:
1. The LCD operator terminal is a small wall- or panel-mounted operator terminal that connects directly to the BACnet LAN. The communication design and messaging structure shall comply with ANSI/ASHRAE Standard 135-2001, BACnet. Each operator terminal shall be able to display any BACnet object from anywhere in the BACnet network.
2. Each of these operator's terminals shall have a keypad and an adjustable backlit LCD, with a simple menu structure to give occupants and technicians intuitive access to system information. It shall have a minimum 4-line by 20-character display to allow an operator to query and adjust system values.
3. The system shall allow the connection of up to 16 LCD operator terminals to each Building Controller. The operator shall have the ability to connect to each of these operator terminals with a laptop computer via an RS-232 cable to gain system access, troubleshooting, and display programming.
4. Provide LCD operator terminals in the locations shown on the drawings.

O. Field Service Tool:
1. Field service tool shall allow technician to view and modify all setpoints and tuning parameters stored in application controller. In addition, technician shall be able to view status of all inputs and outputs on digital readout. Each piece of data shall have a data code associated with it that is customizable.
2. Field service tool shall plug into wall sensor and provide all the functionality specified. Operator workstation shall include the capability to disable operation of the field service tool.

P. Network Connection Tool:
1. Network connection tool shall allow technician to connect a laptop to any MS/TP network or at any MS/TP device and view and modify all information throughout the entire BACnet network. Laptop connection to tool shall be via Ethernet or PTP.
2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in the BACnet standard.

2.3 ELECTRONIC ACTUATORS

A. Manufacturers
1. Belimo
2. Or approved equal

B. Quality Assurance for Actuators and Valves:
1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.

C. Actuators for dampers shall be electric unless otherwise specified, provide actuators as follows:
   1. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify Actuators.
   2. NEMA 2 rated actuator enclosures.
   3. 5-year Manufacturer's Warranty. Two-year unconditional + Three-year product defect from date of installation.
   4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
   5. Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the Actuator.
   6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.
   7. A push button gearbox release shall be provided for all non-spring actuators.
   8. Modulating actuators shall be 24Vac and consume 10VA power or less.
   9. Conduit connectors are required when specified and when code requires it.
   10. Electric damper actuators (including terminal box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable..

2.4 NETWORK COMMUNICATION REQUIREMENTS

A. Wired network communication shall follow the published guidelines for twisted pair BACnet network.

B. Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible. Where communication wire must cross high power wire (deemed as 110VAC or greater) it must do so at right angles.

C. All shields shall be grounded (earth ground) at one point only to eliminate ground loops. All shield grounding shall be done at the controller location with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

D. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices

2.5 SPLICES

A. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers, which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein

2.6 CONDUIT AND FITTINGS

A. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.

B. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.

C. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.

D. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

2.7 RELAYS

A. Relays other than those associated with digital outputs shall be general-purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.

B. Relays associated with digital outputs shall have the ability to override the controlled equipment as a function of the relay. Relays shall be protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.

2.8 IDENTIFICATION

A. Automatic Control Valve Tags
   1. For valves, etc., use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel or aluminum. Attach tags with chain of same materials. For lubrication instructions, use linen or heavy duty shipping tag.
   2. Tag valves with identifying number and system. Number valves by floor level, column location and system served.
   3. Prepare lists of all tagged valves showing location, floor level, and tag number, use. Prepare separate lists for each system. Include copies in each maintenance manual.

B. Wire Tags
   1. All multi-conductor cables in all pull boxes and terminal strip cabinets shall be tagged.
   2. Provide wire Tags as per Division 26.

C. Conduit Tags
   1. Provide tagging or labeling of conduit so that it is always readily observable which conduit was installed or used in implementation of this Work.

D. Miscellaneous Equipment Identification
   1. Screwed-on, engraved black lamicoid sheet with white lettering on all control panels and remote processing panels. Lettering sizes subject to approval.
   2. Inscription, subject to review and acceptance, indicating equipment, system numbers, functions and switches. For panel interior wiring, input/output modules, local control panel device identification.

2.9 ENCLOSURES

A. All controllers, power supplies and relays shall be mounted in enclosures.

B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 4 when installed in other than a clean environment.

C. Enclosures shall be NEMA 3R when installed outdoors or near potential water leakage.

D. Enclosures shall have hinged, locking doors.

E. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 1/8” thick sized appropriately to make label easy to read.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the owners' representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

A. Install in accordance with manufacturer's instructions.

B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from owner’s representative prior to installation.

B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture and high or low temperatures.

C. Identify all equipment and panels. Provide permanently mounted tags for all panels.

D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections—sized to suit pipe diameter without restricting flow.

3.4 INTERLOCKING AND CONTROL WIRING

A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 26.

B. All wiring to be installed in conduit.

C. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.

D. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes

as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.

E. Provide auxiliary pilot duty relays on motor starters as required for control function.

F. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings—coordinate with electrical contractor.

G. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways.

H. Control power supply shall be from emergency power source for all equipment connected to emergency power.

3.5 120V POWER

A. Provide 120V power to control panels from the nearest 208/120V receptacle or mechanical panel. Contractor shall provide minimum 3/4"C-2#10 and 1#10 GRD and connect to a spare circuit in the panel.

B. Coordinate with the Electrical Contractor for spare circuit, and provide information to be included on the Electrical Contractor's As-Built red-line drawings.

C. Electrical installation shall be done per Division 26 specifications.

3.6 Communication Backbone

A. To allow for future expandability, cyber security measures, optimal bandwidth, and enhanced data trending this project shall adhere to the below communication backbone requirements.

B. Fiber Optic Network

1. Required for all project exceeding 5 levels (including rooftops/cellars), 100m between ethernet connections, 250 controllers, or more than 1 type of operational technology residing on the same network (CCTV, lighting, access, etc.).
2. Network edge switches provided for each floor with provisions for expansion capability.
3. Fiber optic cable shall be run between network switches.
4. 1 Centralized Network Controller with Aggregation Switch shall be provided for the building:
   a. Must be a managed fiber / ethernet network with the following network features:
      1) Packet switching and loop detection
      2) Port security with MAC address lockdown and the ability to close all open ports including port connected to a daisy-chain of IP devices.

3) Segregation / isolation with VLAN configuration capabilities. The system shall allow system-wide auto-creation of a VLAN simply by specifying one or more ports to be on that VLAN, and automatically ensure that traffic passes between the selected ports. There must not be any restriction on port location.

4) Web browser based graphical user interface for information logging (network overloads, bandwidth consumption, port status, connection status, and trending)

5) Support both Ethernet and Power over Ethernet (PoE)

6) Support fiber optic backbone(s) with Single-strand, Single-mode Optical Fiber OS1/OS2 9/125 µm, up to 12.5 miles [20.1 km] reach

7) BACnet protocol specific network traffic support and support for all other communication protocols

b. Expansion capability of up to 256 Edge Switches

2. Edge Switches

a. Shall provide 1 per floor

b. Must be compatible with Centralized Network Controller with Aggregation Switch and support the managed network features described above

c. Support both Ethernet, Power over Ethernet (PoE), and Spanning Tree Protocol

d. Support all communication protocols

e. Minimum of 8 RJ45 ethernet ports (all controllers on floor must be connected to Edge switch directly or via daisy-chain IP topology)

3. Security Provisions:

a. Individual VLAN provided per every 2 levels

C. IP (CAT 5 / RJ45) Network

1. BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

2. For all buildings NOT exceeding 5 levels (including rooftops/cellars), 100m between ethernet connections, 250 controllers, or more than 1 type of operational technology residing on the same network (CCTV, lighting, access, etc.):

   a. Ethernet Switches shall be provided as needed to support a fully functional BAS – fiber network shall not be required.

   b. BACnet/IP communication for all BAS manufacturer provided controllers

   c. Modbus TCP shall only be used for third party systems / equipment that do not support BACnet/IP

   d. Modbus RTU and BACnet MS/TP only to be used for third party systems / equipment that do not support BACnet/IP provisions (VFDs, boilers, etc.)

D. Modbus RTU and BACnet MS/TP (RS-485) Network

1. Only to be used for systems / equipment that do not have IP provisions (VFDs, boilers, etc.)

3.7 DDC OBJECT TYPE SUMMARY

A. Provide all database generation.

B. Displays: System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

C. Run Time Totalization: At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trend log: All binary and analog object types (including zones) shall have the capability to be automatically trended.

E. Alarm: All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.

F. Database Save: Provide back-up database for all stand-alone application controllers on disk.

3.8 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.

B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

C. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.9 AS BUILT DOCUMENTATION

A. After completion of the project, insert final approved shop drawings include the following information:
   1. An operator's manual including detailed man-machine interface.
   2. An operator's reference table listing the addresses of all connected input points and output points. Show settings where applicable.
   3. A programmer's manual including all information necessary to perform the programming function.
   4. A language manual including a detailed description of the language used and all routines, modules, etc., used by the system.
   5. Flow charts of the software programs utilized in the system.
   6. Complete program listing file, and parameter listing file for all programs.

B. Provide two (2) AutoCad (latest version) CD and one (1) full size reproducible of each control diagram and equipment schedule reflecting the "as-built" condition. Size shall be the same as the construction document drawings.

3.10 TRAINING

A. Provide application engineer to instruct owner in operation of systems and equipment.

B. Provide system operator's training to include (but not limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of 3 persons.

C. Provide on-site training above as required, up to 16 hours as part of this contract.

3.11 DEMONSTRATION

A. Upon completion of the installation, start up the system and perform all necessary testing, debugging and calibration of each component in the entire system. Perform an acceptance test in the presence of the Owner's Representative. When the system performance is deemed satisfactory in whole or in part of the by the Owner's Representative, the part(s) of the system will be accepted.

B. Provide certificate stating that control system has been tested and adjusted for proper operation.

C. Final system acceptance shall be contingent upon completion of final review and correction of all deficiencies. Satisfactory completion of the operational tests which shall demonstrate compliance with all performance and requirements of the Contract Documents.

PART 4 - SEQUENCE OF OPERATIONS

4.1 GENERAL

A. Design-build contractor to furnish sequence of operations based on installed equipment.

PART 5 - COMMISSIONING

5.1 COMMISSIONING REQUIREMENTS UNDER DDC CONTRACTOR

A. Management:
   1. The Commissioning Agent (CA) is hired directly by the Owner.

2. The CA directs and coordinates the commissioning activities and the reports to the Owner's Representative.
3. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
4. All contractors shall include the cost of commissioning in the contract price. The contractors should be prepared to provide commissioning assistance and follow through until all the commissioned systems have been signed off by the commissioning provider and the Owner's Representative.
5. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training

B. Commissioning requires the participation of Division 23 Instrumentation and Controls contractor to ensure that all systems are operating in a manner consistent with the Design Intent.
   1. The general commissioning requirements and coordination are detailed in Division 1 and Division 23.
   2. Contractor shall be familiar with all parts of Division 1 and Division 23 and the commissioning plan issued by the Commissioning Authority and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. The Test and Balance contractor is responsible for assisting the commissioning agent throughout the entire commissioning process. The work is not complete until the commissioning agent and the Owner Representative have signed off on the commissioned systems.

5.2 COMMISSIONING RESPONSIBILITIES

A. Controls Contractor: The commissioning responsibilities applicable to the controls contractor are as follows (all references apply to commissioned equipment only):
   1. All contractors shall include the cost of commissioning in the contract price. The contractors should be prepared to provide commissioning assistance and follow through until all the commissioned systems have been signed off by the commissioning provider and the Owner's Representative.
   2. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
   3. General Contractor shall attend a commissioning kickoff meeting and other meetings necessary to facilitate the commissioning process.
   4. General Contractor shall provide the Commissioning Provider with normal cut sheets and shop drawing submittals of commissioned equipment.
   5. General Contractor shall provide additional requested documentation, prior to normal O&M manual submittals, to the Commissioning Provider for development of start-up and functional testing procedures.
      a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Provider.
      b. The Commissioning Provider may request further documentation necessary for the commissioning process.

6. General Contractor shall provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the Commissioning Provider for review.
7. Sub-Contractors and design engineers shall assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
8. General Contractor shall provide limited assistance to the Commissioning Provider in preparing the specific functional performance test procedures. Sub-Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
9. General Contractor shall develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the Commissioning Provider for all commissioned equipment. Submit to Commissioning Provider for review prior to startup.
10. During the startup and initial checkout process, execute the mechanical and electrical-related portions of the pre-functional checklists for all commissioned equipment.
11. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the Commissioning Provider.
12. Address current Engineer of Record punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
13. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
14. Provide skilled technicians to perform functional performance testing under the direction of the Commissioning Provider. Assist the Commissioning Provider in interpreting the monitoring data, as necessary.
15. Correct deficiencies (differences between specified and observed performance) as interpreted by the Commissioning Provider, Owner's Representative and Engineer of Record and retest the equipment.
16. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
17. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning.
18. Provide training of the Owner's Representative's operating staff using expert qualified personnel, as specified.
19. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
20. Execute any deferred functional performance testing, witnessed by the Commissioning Provider, according to the specifications.
21. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Controls Contractor. The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in (A) are:
   1. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
      a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
      b. All interactions and interlocks with other systems.
      c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
      d. Written sequences of control for controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
      e. Start-up sequences.
      f. Warm-up mode sequences.
      g. Normal operating mode sequences.
      h. Unoccupied mode sequences.
      i. Shutdown sequences.
      j. Capacity control sequences and equipment staging.
      k. Temperature and pressure control: setbacks, setups, resets, etc.
      l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
      m. Effects of power or equipment failure with all standby component functions.
      n. Sequences for all alarms and emergency shut downs.
      o. Seasonal operational differences and recommendations.
      p. Initial and recommended values for all adjustable settings, set-points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
      q. Schedules, if known.
      r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.
   2. Control Drawings Submittal.
      a. The control drawings shall have a key to all abbreviations.
      b. The control drawings shall contain graphic schematic depictions of the systems and each component.
      c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
      d. Provide a full points list with at least the following included for each point:
         1) Controlled system
         2) Point abbreviation
         3) Point description

4) Display unit
5) Control point or setpoint (Yes / No)
6) Monitoring point (Yes / No)
7) Intermediate point (Yes / No)

e. The Controls Contractor shall keep the Commissioning Provider informed of all changes to this list during programming and setup.

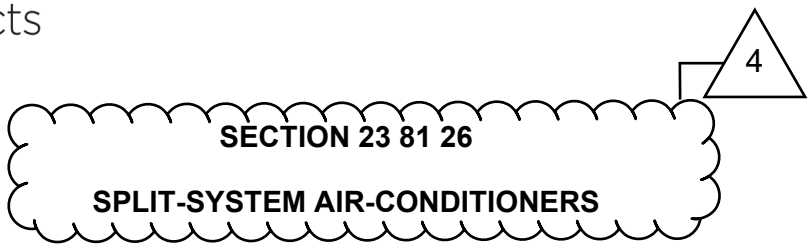
3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
4. Assist and cooperate with the Testing, Adjusting and Balancing (TAB) contractor in the following manner:
   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required pre-functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the Commissioning Provider prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
5. Assist and cooperate with the Commissioning Provider in the following manner:
   a. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system. Assist in the functional testing of all equipment to be commissioned. Provide two-way radios during the testing.
   b. Execute all control system trend logs required in the construction documents and required by the commissioning provider.
6. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
      1) List of devices.
      2) Step-by-step procedures for testing each controller after installation, including:
      3) Process of verifying proper hardware and wiring installation.
      4) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      5) Process of performing operational checks of each controlled component.
      6) Plan and process for calibrating valve and damper actuators and all sensors.
      7) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
      8) A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during

calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.

9) A description of the instrumentation required for testing.
10) Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Provider and TAB contractor for this determination.
11) Provide a signed and dated certification to the Commissioning Provider and Owner’s Representative upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Design Intent and Contract Documents, except functional testing requirements.
12) As well as the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points for all commissioned equipment communicating with the EMS, including mechanical, electrical, and plumbing equipment.

C. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

END OF SECTION



PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes high efficiency split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

B. Warranty

C. Start-up reports

1.06 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:
   1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
   2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

1.07 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For Compressor: Five year(s) from date of Substantial Completion.
      b. For Parts: One year(s) from date of Substantial Completion.
      c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Mitsubishi

B. Daikin

C. LG

2.02 INDOOR UNITS (WALL MOUNT)

A. General:
   1. Indoor unit shall be a wall mounted fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space.
   2. Both refrigerant lines shall be individually insulated from the outdoor unit.
   3. The indoor units shall be equipped with a condensate pan.
   4. The indoor units shall be equipped with a return air thermistor.

5. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
6. The system shall be capable of refrigerant piping up to 164 total feet with a 98 feet maximum vertical difference, without any oil traps or additional components.

B. Unit Cabinet:
1. The cabinet shall be affixed to factory supplied wall hanging brackets and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

C. Fan:
1. The fan shall be direct-drive type with statically and dynamically balanced impeller.

D. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The refrigerant connections shall be flare connections.
3. A mildew resistant, polyethylene air filter and condensate drain pan shall be included as standard equipment.
4. A thermistor will be located on the liquid and gas line to facilitate superheat control and PID temperature control logic.

E. Control:
1. The unit shall be compatible with a Wired or Wireless I/R controller to perform input functions necessary to operate the system.
2. The unit shall be compatible with interfacing with connection to BACnet and LonWorks networks or interfacing with connection to BMS system.

F. Electrical:
1. A separate power supply will be required of 208-230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

G. Accessories:
1. Permanent wall mounted, hard wired remote sensor kit
2. condensate pump
3. Secondary drain pan

2.03 INDOOR UNITS (CASSETTE)

A. General:
1. Indoor unit shall be a suspended cassette type fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation within a conditioned space.
2. Both refrigerant lines shall be individually insulated from the outdoor unit.
3. The indoor units shall be equipped with a condensate pan.
4. The indoor units shall be equipped with a return air thermistor.

5. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.

B. Unit Cabinet:
1. The cabinet shall be affixed to factory supplied wall hanging brackets and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

C. Fan:
1. The fan shall be direct-drive type with statically and dynamically balanced impeller.

D. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The refrigerant connections shall be flare connections.
3. A mildew resistant, polyethylene air filter and condensate drain pan shall be included as standard equipment.
4. A thermistor will be located on the liquid and gas line to facilitate superheat control and PID temperature control logic.

E. Control:
1. The unit shall be compatible with a Wired or Wireless I/R controller to perform input functions necessary to operate the system.
2. The unit shall be compatible with interfacing with connection to BACnet and LonWorks networks or interfacing with connection to BMS system.

F. Electrical:
1. A separate power supply will be required of 208-230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

G. Accessories:
1. Permanent wall mounted, hard wired remote sensor kit
2. Integral condensate pump
3. Secondary drain pan

2.04 OUTDOOR UNITS

A. General:
1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a Daikin swing compressor, motors, fan, condenser coil, electronic expansion valves, solenoid valves, 4 way valve, distribution headers, capillaries, filters, shut off valves, service ports and suction accumulator.
2. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for re-programming.

3. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
4. The following safety devices shall be included on the condensing unit; high pressure switch, outdoor fan driver overload protector, Inverter overload protector, fusible plugs, fuse.

B. Unit Cabinet:
1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
2. The outdoor unit will come furnished with four (4) mounting feet, mounted across the base pan, to allow bolting to a cement pad.

C. Fan:
1. The condensing unit shall consist of one propeller type, direct-drive fan motor that has multiple speed operation via a DC (digitally commutating) inverter.
2. The fan motor shall have inherent protection and permanently lubricated bearings.

D. Condenser Coil:
1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1, rated for up to 1000 hours salt spray.
3. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

E. Compressor:
1. The inverter driven compressor shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed swing type.
2. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
3. The compressor shall be equipped with a crankcase heater, high pressure safety switch and internal thermal overload protector.

2.05 ACCESSORIES

A. Provide BACnet and MODBUS Interface for all components.

B. Provide relay for interlock to fan.

C. Thermostat: Wireless control compressor and evaporator fan, with the following features:
1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure as detailed on the drawings.

C. Install roof-mounted, compressor-condenser components on equipment supports as detailed on the drawings.

D. Equipment Mounting:
   1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

E. Install and connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

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

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
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.

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

E. Prepare test and inspection reports.

3.04 STARTUP SERVICE

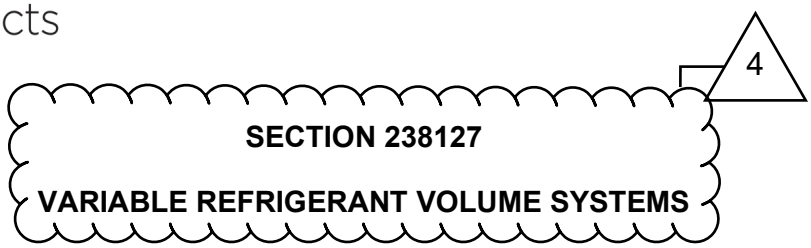
A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions. Engage Trane factory representative in start-up service.

3.05 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units. Provide a minimum of 4 hours.

END OF SECTION



PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. VRF Heat Recovery Systems and accessories
2. VRF Heat Pump Systems and accessories

B. Related Sections:
1. Section 230000 “General Mechanical Requirements”
2. Section 233113 "Metal Ducts"
3. Section 233300 "Air Duct Accessories”

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, static pressure, sound power, and furnished specialties and accessories.
2. Include data on electrical requirements and connections points. Included recommended wire and fuse sizes or MCA, safety and start-up instructions.
3. Include overall dimensions as well as installation, operation and service clearances.
4. Indicate unit shipping, installation and operating weights.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Include refrigerant piping layout
3. Include diagrams for power, signal, and control wiring.
4. Any deviation from specification or drawings shall be clearly identified in the submittals.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, 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. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

6. Perimeter moldings.

B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017800 "Closeout Submittals," include the following:

a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish 1 spare filters for each filter installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. All units shall be ETL listed.

1.8 COORDINATION

A. Coordinate layout and installation of VRF systems and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.9 WARRANTY

A. Special Warranty: System to be installed by a certified installer of the specified VRF system that meets all the manufacturer’s requirements for installation and that has taken all the required service courses. Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

Warranty Period : 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Mitsubishi, Mitsubishi Electric USA

B. Daikin North America, LLC

C. Toshiba-Carrier

2.2 HEAT RECOVERY SYSTEM

A. System Description
   1. The air conditioning system shall be a variable capacity heat recovery system as specified.
   2. The system shall consist of multiple evaporators, heat recovery control unit, joints and headers, a refrigeration distribution system using PID control and an outdoor condenser unit.
   3. The condenser shall be a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant.
   4. The condensing unit may connect an indoor evaporator capacity ranging from 50% to 150% of the condensing unit nominal capacity. All zones are each capable of operating separately with individual temperature control.
   5. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance.
   6. The outdoor condensing unit shall be connected to multiple indoor units as shown on plans.
      a. The indoor units shall be connected to the condensing unit utilizing piping joints, branch selectors, and headers to ensure correct refrigerant flow and balancing.
   7. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all the indoor units associated with each heat recovery control unit. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller or a BMS interface.

B. Heat Recovery Control Unit:
   1. Heat recovery shall be designed and manufactured by the same manufacturer of VRF indoor and outdoor unit(s).
   2. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.

C. Condensing Unit
   1. General:
      a. Each system shall consist of one, two or three air source outdoor unit frame.
      b. Frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kit in conjunction with field provided interconnecting pipe to form a common refrigerant circuit.
      c. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
      d. Refrigerant circuit configuration for the condensing unit:
         1) Shall consist of inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut-off valves, oil separators, service ports, and refrigerant accumulators.
         2) The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, refrigerant rated copper pipe, piped together with manufacturer supplied heat recovery unit(s) and y-branches, as may be required, connected to multiple (ducted, non-ducted or mixed

combination) indoor units to control the heat recovery mode operations of the VRF system effectively and efficiently. Other pipe materials, if used, shall be submitted to the engineer of record for review and approval for performance and construction compliance prior to procurement.

3) All refrigerant pipe, y-branches, elbows, and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less than the minimum called for by the local building code, local energy code, authority having jurisdiction or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

e. Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s).

f. The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug outdoor unit shall have a fusible plug.

g. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, compressor, contacts, relay(s), power and communications wiring necessary.

2. Unit Cabinet:
   a. Unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 500 hours.
   b. The front panels of the outdoor units shall be removable type for access to internal components.
   c. A smaller service access panel, shall be provided to access the following:
      1) Service tool connection
      2) DIP switches
      3) Auto addressing
      4) Error codes
   d. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front or through the bottom of the unit.
3. Fan:
   a. The fan(s) motor shall be equipped with permanently lubricated bearings.
   b. The fan motor shall be variable speed.
   c. The fan shall have a raised guard to help prevent contact with moving parts.
   d. The cabinet shall discharge air vertically or both vertically and horizontally if optional factory provisions permit.
   e. The fans(s) shall be mounted for quiet operation.
   f. Motor shall be protected by internal thermal overload protection.
   g. The cabinet shall have DIP switch setting to raise external static pressure up to 0.23 in-wg.

4. Condenser Coil:
   a. The outdoor unit shall have a factory-built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. The copper tubes shall have inner groves.

c. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.
   1) Alternatives must provide a drain pan heater to enable adequate defrosting of the unit in defrost operation.
d. The aluminum fins shall be coated by a highly corrosion resistant epoxy resin coating, designed to perform in corrosive environments such as contaminated and humid conditions. The heat exchanger protective coating shall include a hydrophilic coating which minimizes moisture buildup on the fin heat exchanger. The heat exchanger shall have been tested to the following conditions which establish the minimum allowable performance which all alternates must comply:
   1) ASTM B-117 Salt spray test – 1500 hours with no corrosion,
   2) Acid salt test – 900 hours .02% corrosion,
   3) ASM corrosion test – 3,000 hours. The coating shall be certified by Underwriters Laboratories and per ISO 21207.
e. The outdoor unit coil shall be tested to a pressure of 551 psig.
f. The coil for each cabinet shall have 14 Fins per Inch (FPI).
g. All the outdoor units shall have a 3 rows heat exchanger.
h. The cabinet shall have a coil guards on all sides.

5. Compressor:
   a. Each 6, 8, 10 ton cabinet shall be equipped with one hermetically sealed, inverter driven scroll compressor.
   b. The 12 thru 20 ton cabinet shall be equipped with two hermetically sealed, inverter driven scroll compressors.
   c. Each inverter driven scroll compressor shall be capable of operating in a frequency range from 15 Hz to 150 Hz with control in 0.5 Hz increments.
   d. The compressor(s) shall be equipped with a crankcase heater.
   e. The compressor shall use a factory charge of Polyvinyl Ether (PVE) oil.
   f. The compressor bearing(s) shall have Teflon™ coating.
   g. The compressor(s) shall be protected with:
      1) High Pressure switch
      2) Over-current /under current protection
      3) Phase failure
      4) Phase reversal
   h. Standard, non-inverter driven compressors shall not be permitted
   i. At complete stop of the compressor, the compressor's permanent magnets will position the rotor into the optimum position for a low torque start.
   j. The capacity control range shall be as low as 5% to 100%.
   k. The compressor's motor shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
   l. Each compressor shall be equipped with a high pressure safety switch, and internal thermal overload protector.
   m. Oil separators shall be standard with the equipment together with an intelligent oil management system.
   n. The compressor shall be spring mounted to avoid the transmission of vibration eliminating the standard need for spring insolation.
   o. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a

proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition for single module and manifolded systems.

p. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours. When connected to a central control system sequential start is activated for all system on each network.

6. Oil Management
   a. The system shall have a high pressure oil return to ensure a consistent film of oil on all moving compressor parts at low speed. Oil is returned to compressor through a separate oil injection pipe.
      1) Oil return system shall maintain high side pressure return to the compressor
   b. The system shall be provided with a centrifugal oil separator designed to extract oil from the oil/refrigerant gas stream leaving the compressor and return the extracted oil to the compressor oil sump.
   c. The system shall have an oil level sensor in the compressor to provide direct oil level sensing.
   d. The system shall only initiate an oil return cycle if the oil level is too low.
   e. Timed oil return operations or non-oil level sensing systems shall not be permitted.
7. Refrigerant Management
   a. System shall have advanced refrigerant control functions that optimize operating efficiency at all ambient operating conditions.
   b. Accumulator shall be equipped with controls that vary the amount of refrigerant charge being circulated based on operating mode.
   c. Controls shall vary the coil circuiting between parallel and series configurations and be able to change flow direction in response to multiple refrigerant monitoring parameters and operating conditions.
   d. Compressors shall be equipped with an intermediary port that introduces additional refrigerant to the compression chamber based on multiple refrigerant system monitoring parameters.
8. Sound Levels
   a. The sound pressure level standard shall be that value as listed by the manufacturer for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time or via an external input.
9. Sensors
   a. Each single cabinet shall have
      1) Suction temperature sensor
      2) Discharge temperature sensor
      3) High Pressure sensor
      4) Low Pressure sensor
      5) Outdoor temperature sensor
      6) Outdoor unit heat exchanger temperature sensor

D. Fan Coil Unit
   1. General
      a. Unit shall be factory assembled, wired, piped and run tested.

b. Unit shall be horizontal ducted, ceiling mounted, vertical ducted or wall mount ductless as indicated on the plans
c. Unit shall be designed to be installed for indoor application.
d. The supply air shall be flanged for field installed ductwork that shall not exceed the external static pressure limitation of the unit.
e. Unit shall be capable to be installed with heat recovery VRF system.

2. Casing/Panel
   a. Unit case shall be manufactured using galvanized steel plate.
   b. The cold surfaces of the unit shall be covered internally with an insulating material.
   c. The cold surfaces of the unit shall be covered externally with M-Class sheet insulation
   d. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
   e. Unit shall be provided with hanger brackets designed to support the unit weight on four corners.
   f. Hanger brackets shall have pre-punched holes designed to accept field supplied, all thread rod hangers.
3. Cabinet Assembly
   a. Unit shall be equipped with factory installed temperature thermistors for
      1) Return air
      2) Refrigerant entering coil.
      3) Refrigerant leaving coil.
   b. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
   c. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
   d. Unit shall have the following functions as standard
      1) Self-diagnostic function
      2) Auto restart function
      3) Auto changeover function
      4) Auto operation function
      5) Child lock function
      6) Forced operation
      7) Dual thermistor control
      8) Sleep mode
      9) External static pressure (ESP) control
4. Fan Assembly
   a. The unit shall have direct drive fan(s).
   b. If multiple fans, fans shall be mounted on a common shaft.
   c. The fan motor shall be Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
   d. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
   e. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
   f. In cooling mode, the indoor fan shall have the following settings: Low, Med, High and Auto.
   g. In heating mode, the indoor fan shall have the following settings: Low, Med, High and Auto.

h. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
i. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
j. Unit shall be designed for high speed air volume against an external static pressure of up to 1.0" water gauge. External static pressure capacity shall be determined with consideration of a dirty filter at the point of change out.

5. Filter Assembly
   a. Horizontal ducted units shall be provided with a field mounted return filter box. Filter shall be high-efficiency 2" MERV 13 not to exceed external static pressure limitation of the high static ducted indoor unit.
   b. Ductless wall mount units shall have a factory supplied removable, washable filter.
6. Coil Assembly
   a. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. Unit shall have minimum of 2 rows of coils.
   c. Unit shall have a factory supplied condensate drain pan below the coil.
   d. Horizontal unit shall be installed and wired condensate drain pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.
   e. Vertical unit shall be designed for gravity drain.
   f. Unit drain pan shall be provided with a secondary drain port/plug allowing pan to be drained for service.
   g. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
   h. Unit shall have provision of 45° flare refrigerant pipe connections
   i. The coil shall be factory pressure tested at a minimum of 551 psig.
   j. All refrigerant piping from outdoor unit or heat recovery control unit to indoor unit shall be field insulated.
7. Microprocessor Control
   a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
   b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, 2 core, stranded and shielded communication cable.
   c. The unit controls shall operate the indoor unit using one of the five operating modes:
      1) Auto changeover
      2) Heating
      3) Cooling
      4) Dry
      5) Fan only

2.3 HEAT PUMP SYSTEM

A. System Description
1. The air conditioning system shall be a variable capacity heat pump (heating or cooling) system as specified. The heating portion is to be disabled so that the system operates as cooling only.

2. The system shall consist of multiple evaporators, joints and headers, a refrigeration distribution system using PID control and an outdoor condenser unit.
3. The condenser shall be a direct expansion (DX), air-cooled heat exchanger, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant.
4. The condensing unit may connect an indoor evaporator with combined capacity ranging from 50% up to 150% of the condensing unit nominal capacity. All zones are each capable of operating separately with individual temperature control.
5. The outdoor condensing unit shall be connected to two indoor units.
   a. The indoor units shall be connected to the condensing unit utilizing piping joints and headers to ensure correct refrigerant flow and balancing.
6. Operation of the system shall permit either individual cooling or heating of all indoor unit simultaneously. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller or a BMS interface but all indoor units shall function in the mode (heating or cooling) dictated by the outdoor condensing unit.

B. Condensing Unit
   1. General:
      a. The condensing unit is designed specifically for use with VRF series components.
      b. The condensing unit shall be factory assembled in the USA and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of the inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant accumulator.
      c. Liquid and suction lines must be individually insulated per manufacturer recommendation between the condensing and indoor units.
      d. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
      e. The connection ratio of indoor units to condensing unit shall be permitted up to 150%.
      f. Each condensing system shall be able to support the connection of up to 64 indoor units dependent on the model of the condensing unit.
      g. The sound pressure level standard shall be that value as listed in the engineering manual for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during nighttime or via an external input
      h. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
      i. The unit shall incorporate an auto-charging feature to ensure optimum performance. Manual changing should be support with a minimum of 2 hours of system operation data to ensure correct operation
      j. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
      k. The following safety devices shall be included on the condensing unit, high pressure sensor and switch, low pressure switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.

l. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
m. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation
n. The condensing unit shall be capable of heating operation at 0°F dry bulb ambient temperature without additional low ambient controls or an auxiliary heat source.

2. Unit Cabinet:
   a. Unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 500 hours.
   b. The front panels of the outdoor units shall be removable type for access to internal components.
   c. A smaller service access panel, shall be provided to access the following:
      1) Service tool connection
      2) DIP switches
      3) Auto addressing
      4) Error codes
   d. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front or through the bottom of the unit.
3. Fan:
   a. The fan(s) motor shall be equipped with permanently lubricated bearings.
   b. The fan motor shall be variable speed.
   c. The fan shall have a raised guard to help prevent contact with moving parts.
   d. The cabinet shall discharge air vertically or both vertically and horizontally if optional factory provisions permit.
   e. The fans(s) shall be mounted for quiet operation.
   f. Motor shall be protected by internal thermal overload protection.
   g. The cabinet shall have DIP switch setting to raise external static pressure up to 0.23 in-wg.
   h. The fan(s) motor shall be equipped with permanently lubricated bearings.
   i. The fan motor shall be variable speed.
   j. The fan shall have a raised guard to help prevent contact with moving parts.
   k. The cabinet shall discharge air vertically or both vertically and horizontally if optional factory provisions permit.
4. Condenser Coil:
   a. The outdoor unit shall have a factory-built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. The copper tubes shall have inner groves.
   c. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.
      1) Alternatives must provide a drain pan heater to enable adequate defrosting of the unit in defrost operation.
   d. The aluminum fins shall be coated by a highly corrosion resistant epoxy resin coating, designed to perform in corrosive environments such as contaminated and humid conditions. The heat exchanger protective coating shall include a hydrophilic coating which minimizes moisture buildup on the fin heat exchanger. The heat exchanger shall have been tested to the

following conditions which establish the minimum allowable performance which all alternates must comply:
1) ASTM B-117 Salt spray test – 1500 hours with no corrosion,
2) Acid salt test – 900 hours .02% corrosion,
3) ASM corrosion test – 3,000 hours. The coating shall be certified by Underwriters Laboratories and per ISO 21207.

e. The outdoor unit coil shall be tested to a pressure of 551 psig.
f. The coil for each cabinet shall have 14 Fins per Inch (FPI).
g. All the outdoor units shall have a 3 rows heat exchanger.
h. The cabinet shall have a coil guards on all sides.

5. Compressor:
a. Each 6, 8, 10 ton cabinet shall be equipped with one hermetically sealed, inverter driven scroll compressor.
b. The 12 thru 20 ton cabinet shall be equipped with two hermetically sealed, inverter driven scroll compressors.
c. Each inverter driven scroll compressor shall be capable of operating in a frequency range from 15 Hz to 150 Hz with control in 0.5 Hz increments.
d. The compressor(s) shall be equipped with a crankcase heater.
e. The compressor shall use a factory charge of Polyvinyl Ether (PVE) oil.
f. The compressor bearing(s) shall have Teflon™ coating.
g. The compressor(s) shall be protected with:
1) High Pressure switch
2) Over-current /under current protection
3) Phase failure
4) Phase reversal
h. Standard, non-inverter driven compressors shall not be permitted
i. At complete stop of the compressor, the compressor's permanent magnets will position the rotor into the optimum position for a low torque start.
j. The capacity control range shall be as low as 5% to 100%.
k. The compressor's motor shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
l. Each compressor shall be equipped with a high pressure safety switch, and internal thermal overload protector.
m. Oil separators shall be standard with the equipment together with an intelligent oil management system.
n. The compressor shall be spring mounted to avoid the transmission of vibration eliminating the standard need for spring insolation.
o. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition for single module and manifolded systems.
p. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours. When connected to a central control system sequential start is activated for all system on each network.

6. Oil Management

a. The system shall have a high pressure oil return to ensure a consistent film of oil on all moving compressor parts at low speed. Oil is returned to compressor through a separate oil injection pipe.
   1) Oil return system shall maintain high side pressure return to the compressor
b. The system shall be provided with a centrifugal oil separator designed to extract oil from the oil/refrigerant gas stream leaving the compressor and return the extracted oil to the compressor oil sump.
c. The system shall have an oil level sensor in the compressor to provide direct oil level sensing.
d. The system shall only initiate an oil return cycle if the oil level is too low.
e. Timed oil return operations or non-oil level sensing systems shall not be permitted.

7. Refrigerant Management
   a. System shall have advanced refrigerant control functions that optimize operating efficiency at all ambient operating conditions.
   b. Accumulator shall be equipped with controls that vary the amount of refrigerant charge being circulated based on operating mode.
   c. Controls shall vary the coil circuiting between parallel and series configurations and be able to change flow direction in response to multiple refrigerant monitoring parameters and operating conditions.
   d. Compressors shall be equipped with an intermediary port that introduces additional refrigerant to the compression chamber based on multiple refrigerant system monitoring parameters.
8. Sound Levels
   a. The sound pressure level standard shall be that value as listed by the manufacturer for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time or via an external input.
9. Sensors
   a. Each single cabinet shall have
      1) Suction temperature sensor
      2) Discharge temperature sensor
      3) High Pressure sensor
      4) Low Pressure sensor
      5) Outdoor temperature sensor
      6) Outdoor unit heat exchanger temperature sensor

C. Fan Coil Unit
1. General
   a. Unit shall be factory assembled, wired, piped and run tested.
   b. Unit shall be horizontal ducted, ceiling mounted, vertical ducted or wall mount ductless as indicated on the plans
   c. Unit shall be designed to be installed for indoor application.
   d. The supply air shall be flanged for field installed ductwork that shall not exceed the external static pressure limitation of the unit.
   e. Unit shall be capable to be installed with heat pump VRF system.
2. Casing/Panel
   a. Unit case shall be manufactured using galvanized steel plate.
   b. The cold surfaces of the unit shall be covered internally with an insulating material.

c. The cold surfaces of the unit shall be covered externally with M-Class sheet insulation
d. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
e. Unit shall be provided with hanger brackets designed to support the unit weight on four corners.
f. Hanger brackets shall have pre-punched holes designed to accept field supplied, all thread rod hangers.

3. Cabinet Assembly
   a. Unit shall be equipped with factory installed temperature thermistors for
      1) Return air
      2) Refrigerant entering coil.
      3) Refrigerant leaving coil.
   b. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
   c. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
   d. Unit shall have the following functions as standard
      1) Self-diagnostic function
      2) Auto restart function
      3) Auto operation function
      4) Child lock function
      5) Forced operation
      6) Dual thermistor control
      7) Sleep mode
      8) External static pressure (ESP) control
4. Fan Assembly
   a. The unit shall have direct drive fan(s).
   b. If multiple fans, fans shall be mounted on a common shaft.
   c. The fan motor shall be Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
   d. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
   e. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
   f. In cooling mode, the indoor fan shall have the following settings: Low, Med, High and Auto.
   g. Heating mode to be disabled.
   h. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
   i. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
   j. Unit shall be designed for high speed air volume against an external static pressure of up to 1.0” water gauge. External static pressure capacity shall be determined with consideration of a dirty filter at the point of change out.
5. Filter Assembly
   a. Horizontal ducted units shall be provided with a field mounted return filter box. Filter shall be high-efficiency 2” MERV 13 not to exceed external static pressure limitation of the high static ducted indoor unit.
   b. Ductless wall mount units shall have a factory supplied removable, washable filter.

6. Coil Assembly
   a. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
   b. Unit shall have minimum of 2 rows of coils.
   c. Unit shall have a factory supplied condensate drain pan below the coil.
   d. Horizontal unit shall be installed and wired condensate drain pump capable of providing minimum 27.5-inch lift from bottom surface of the unit.
   e. Vertical unit shall be designed for gravity drain.
   f. Unit drain pan shall be provided with a secondary drain port/plug allowing pan to be drained for service.
   g. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
   h. Unit shall have provision of 45° flare refrigerant pipe connections
   i. The coil shall be factory pressure tested at a minimum of 551 psig.
   j. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.
7. Microprocessor Control
   a. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
   b. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, 2 core, stranded and shielded communication cable.
   c. The unit controls shall operate the indoor unit using one of the five operating modes:
      1) Heating – Disabled.
      2) Cooling
      3) Dry
      4) Fan only

D. ACCESSORIES
1. Provide BACnet and MODBUS Interface for all components, include heat recovery unit and heat recovery box.
2. Provide wired thermostats.
3. Provide relay for interlock to fans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive equipment for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

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

3.2 INSTALLATION

A. Install VRF equipment level and plumb.

B. Install VRF equipment to comply with NFPA 90A.

C. Install ground-mounted, compressor-condenser components on minimum 4-inch-thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Suspend indoor fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation.

H. Install new filters in each indoor fan-coil unit within two weeks after Substantial Completion.

3.3 FIELD-INSTALLED REFRIGERANT PIPING

A. Connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

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

C. Piping shall be copper with joints brazed with 15% silver, silphos brazing rod.

D. Elbows shall be of the long radius type.

E. Liquid and vapor piping shall be insulated with ¾” thick closed cell rubberized insulation.

F. Piping shall be secured to structure with straps, taking care to ensure that the liquid line does not contact the structure and that the insulation is not torn.

G. Piping shall be purged with dry nitrogen prior to evacuation and charging with refrigerant.

H. Connect supply-air and return-air ducts to indoor fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

K. Consult manufacturer's long line set application guide for piping lengths that exceed 80 feet. Provide the following accessories for long line applications:
   1. Liquid line solenoid valve at outdoor unit.
   2. Thermal expansion valve.
   3. Crank case heater.
   4. Start capacitor and relay.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

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

3.6 DEMONSTRATION

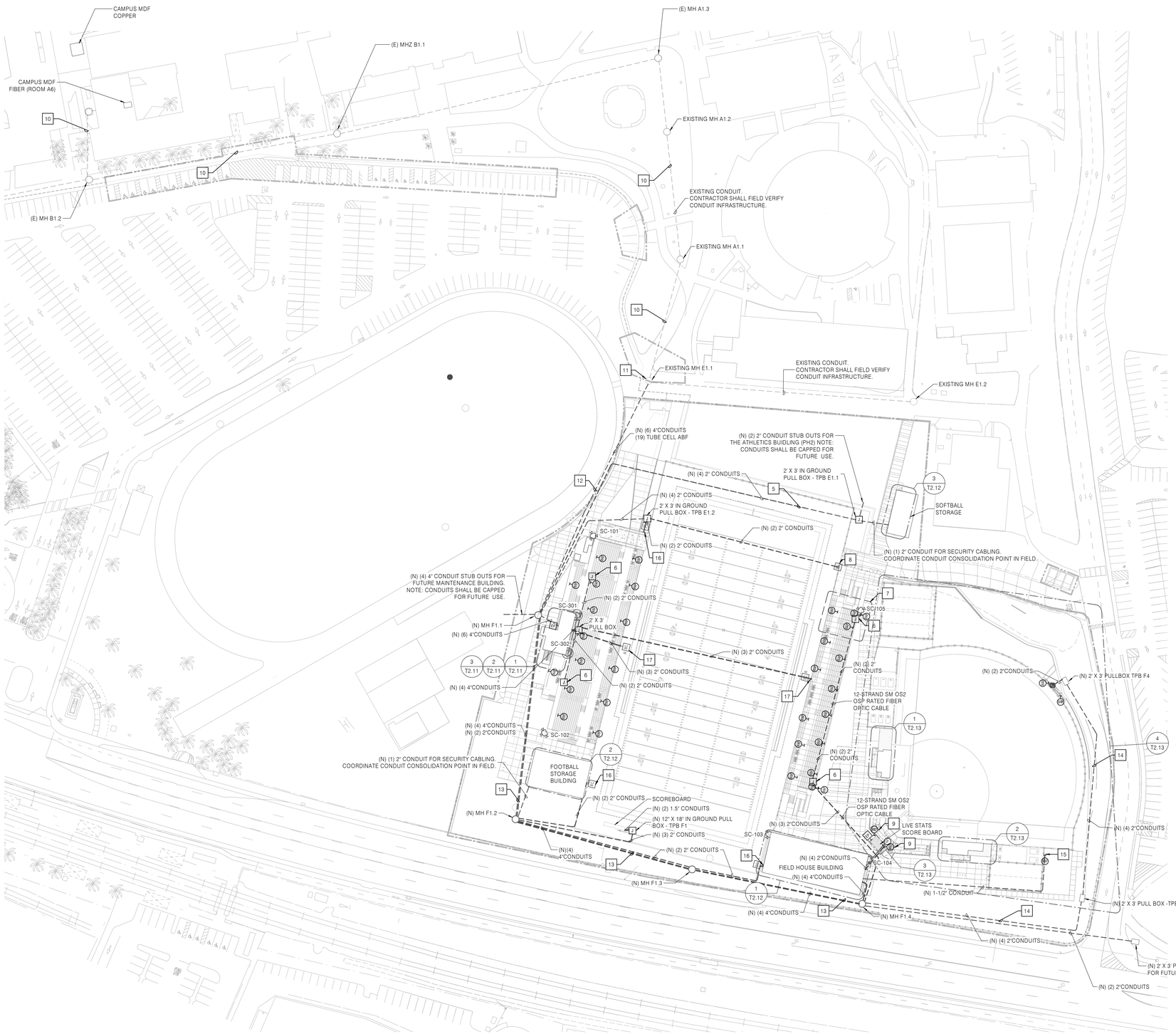
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 238219

If the sheet is not 30"x42", it is a reduced print. Scale Accordingly

GENERAL NOTES

1. TELECOMMUNICATION PULL BOXES LOCATED ON THE FIELD WILL INCLUDE PULL BOX COVER WITH A TOP LID.
2. ALL TELECOMMUNICATION MANHOLES SHALL BE 5'X 7.5' (JENSEN PRECAST PART NO. K466 SERIES U.O.N. REFER TO DETAIL 6/T6.18 FOR DETAILS.
4.



KEYNOTES

1. PROVIDE AND INSTALL INFRASTRUCTURE FOR FUTURE ACCESS CONTROL INSTALLATION.
2. PROVIDE AND INSTALL 2" CONDUIT SLEEVE FROM IDF 113 FOR CABLE PASSTHROUGH.
3. PROVIDE AND INSTALL 2" CONDUIT SLEEVE FROM PRESS BOX FPB202 FOR CABLE PASSTHROUGH.
4. STUB (2) 2" UNDERGROUND CONDUIT INTO 12" X18" HANDHOLE FOR FUTURE CABLE PATH CONNECTION TO FUTURE BUILDING.
5. PROVIDE AND INSTALL (3) 2" CONDUITS FOR FUTURE SCOREBOARD.
6. PROVIDE AND INSTALL 24"X12"X8" NEMA 4 RATED SURFACE MOUNT PULL BOX. PULL BOX WILL BE A CONSOLIDATED POINT FOR INDIVIDUAL WIFI CABLE INFRASTRUCTURE.
7. WAP DEVICES WITHIN THIS AREA WILL BE ROUTED TO PULL BOX AND CONNECTED TO SWITCH.
8. PEDESTAL MOUNTED BROADCAST CABINET. REFER TO DETAIL 6A/T6.16.
9. EXTERIOR WAP ANTENNA LOCATION ON CMU WALL. WIRELESS ACCESS POINT MOUNTED ON THE INSIDE OF THE BUILDING WITH AN OUTDOOR RATED ANTENNA ON THE EXTERIOR FACADE, REFER TO DETAIL 2/T6.15. NOTE THAT CONDUIT CANNOT BE IN CMU CELLS WITH REINFORCEMENT, REFER TO DETAIL 8/S0.21.
10. PROVIDE AND INSTALL FUTUREPATH DURA-LINE 19 AIR BLOWN FIBER TUBE CELL FROM CAMPUS MDF TO EXISTING VAULT SOUTHWEST OF BUILDING O. PROVIDE AND INSTALL (1) 12-STRAND SINGLE-ODE AFL/DURA-LINE AIR BLOWN FIBER FROM CAMPUS MDF TO FOOTBALL PRESS BOX IDF. PROVIDE AND INSTALL 25-PAIR COPPER BACKBONE CABLE FROM CAMPUS MDF HOME RUN TO FOOTBALL FIELD PRESS BOX IDF.
11. PROVIDE AND INSTALL AIR BLOWN FIBER SPLICE CASE, SPLICE 19-TUBE CELL TO 7-TUBE CELL.
12. PROVIDE AND INSTALL FUTUREPATH DURA-LINE 7 AIR BLOWN FIBER TUBE CELL FROM EXISTING VAULT AT BUILDING 9 TO FOOTBALL PRESS BOX IDF.
13. PROVIDE AND INSTALL FUTUREPATH DURA-LINE 7 AIR BLOWN FIBER TUBE CELL FROM FOOTBALL PRESS BOX IDF TO FIELD HOUSE IDF. PROVIDE AND INSTALL (1) 12-STRAND SINGLE-MODE AFL/DURA-LINE AIR BLOWN FIBER. PROVIDE AND INSTALL 25-PAIR COPPER BACKBONE CABLE.
14. PROVIDE AND INSTALL CONVENTIONAL FIBER CABLE FROM FIELD HOUSE IDF TO SOFTBALL FIELD SCOREBOARD. TERMINATE SCOREBOARD SIDE WITH WALL MOUNT TERMINATION ENCLOSURE.
15. WIFI ACCESS POINT SHALL BE MOUNTED INSIDE OBERON 3032 12 IN. DIAMETER NETPOINT™ ROTOMOLDED POLYETHYLENE PLASTIC WI-FI ACCESS POINT BOLLARD. REFER TO DETAIL 3/T6.16.
16. SURFACE WALL-MOUNTED BROADCAST CABINET WITH PEDESTAL. CONDUITS WILL BE SURFACE MOUNTED WITHIN PEDESTAL ENCLOSURE. REFER TO DETAIL 6B/T6.16.
17. IN-WALL RECESSED-MOUNTED BROADCAST CABINET. REFER TO DETAIL 6C/T6.16.

N

1" = 50'-0"

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ISSUE:

NO.	ISSUED	DATE
3	ADDENDUM 3	02/08/2022
4	ADDENDUM 4	02/20/2022

Keynotes:

Notes:

Consultant:
P2S ENG
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San Diego | San Jose
p2sInc.com

Consultant's Project No. J9781

Facility:
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1140 WEST MISSION ROAD
SAN MARCOS, CA 92069

Project:
PALOMAR COLLEGE - ATHLETICS PH1 - FOORBALL & SOFTBALL FIELDS

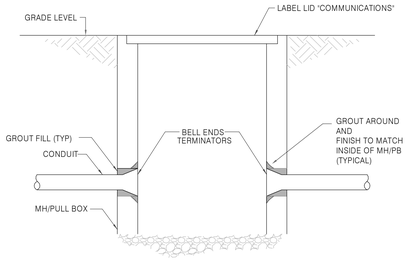
Sheet:
SITE PLAN

DSA APPROVED SET

File No.: 37-C1	**A No.: 04-120240**
Date: 01.18.2022	**Client Project No.:** 5015030000

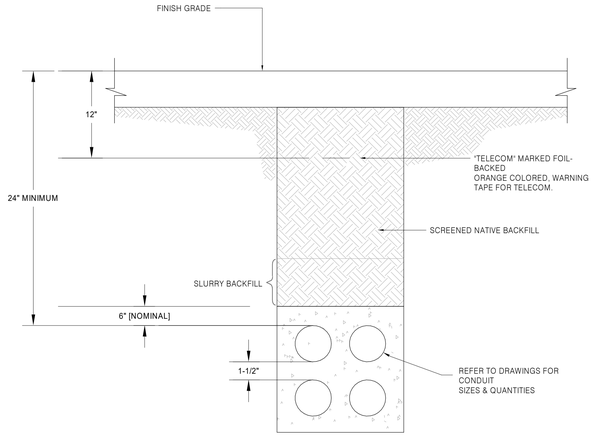
Sheet:

T1.11



7 TYPICAL (E) MH/PULL BOX CONDUIT TERMINATIONS

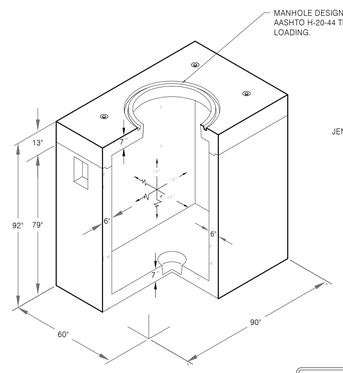
SCALE: NONE



TYPICAL SEPARATIONS REQUIRED FOR CONCRETE ENCASEMENT. SPACERS ARE REQUIRED AT 10' INTERVALS TO FACILITATE ENCASEMENT FLOW BETWEEN DUCTS

6 TELECOM TRENCH

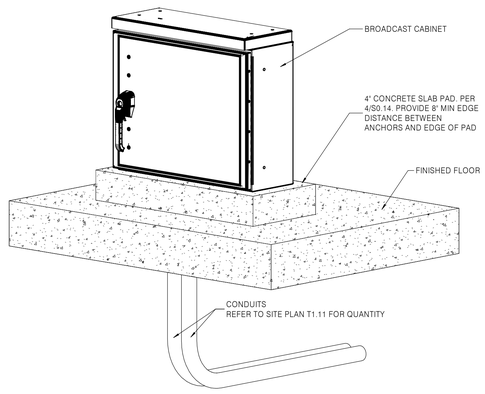
SCALE: NONE



MINIMUM EXCAVATION SIZE: 6'-0" x 8'-6" x DEPTH REQ'D.

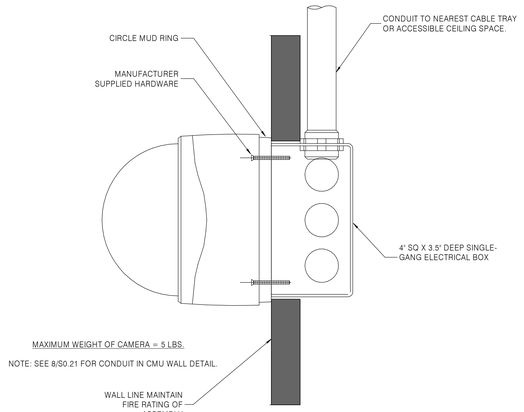
5 TELECOM MANHOLE

SCALE: NONE



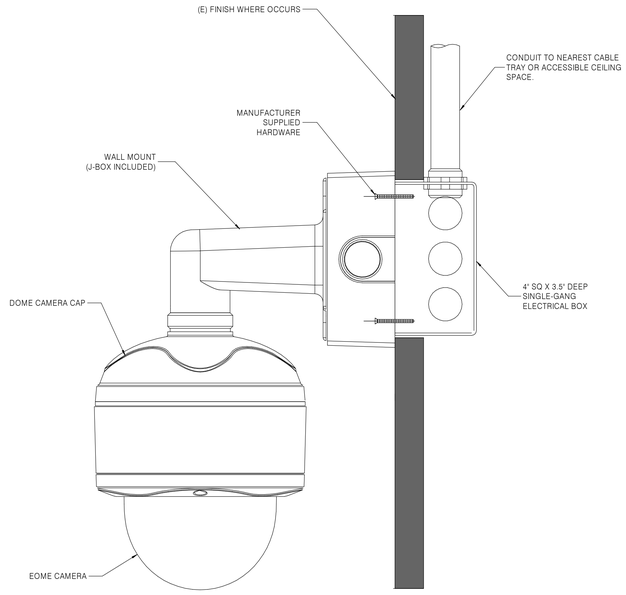
4 TYP. BROADCAST CABINET MOUNTED ON CONCRETE SLAB PAD

SCALE: NONE



3 TYP. DOME WALL SURFACE MOUNTED CAMERA

SCALE: NONE

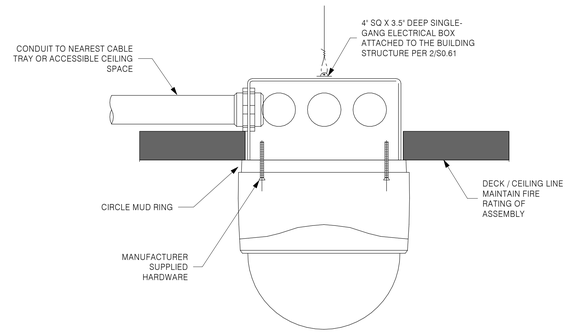


MAXIMUM WEIGHT OF CAMERA = 10 LBS.

NOTE: SEE 8/S0.21 FOR CONDUIT IN CMU WALL DETAIL.

2 TYP. DOME WALL PENDANT MOUNTED CAMERA DETAIL

SCALE: NONE



MAXIMUM WEIGHT OF CAMERA = 5 LBS.

1 TYP. DOME CEILING SURFACE MOUNTED CAMERA DETAIL

SCALE: NONE

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4	ADDENDUM 4	02/20/2022

Keynotes:

Notes:

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SAN MARCOS, CA 92069

Project:
PALOMAR COLLEGE - ATHLETICS PH1 - FOORBALL & SOFTBALL FIELDS

Sheet:
DETAILS

DSA APPROVED SET

File No.: 37-C1	**A No.: 04-120240**
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Sheet:
T6.18