ADDENDUM NO. 2

to the Contract Documents
for the Construction of the

USCBP – GENERAL AVIATION CUSTOMS FACILITY

at
ITHACA TOMPKINS REGIONAL AIRPORT
TOMPKINS COUNTY, NEW YORK

TO ALL HOLDERS OF CONTRACT DOCUMENTS:

Your attention is directed to the following interpretations of changes in and additions to the Contract Documents for the construction of the **USCBP – GENERAL AVIATION CUSTOMS FACILITY** project at the Ithaca Tompkins Regional Airport, Tompkins County, New York. This Addendum is part of the Contract Documents in accordance with the provisions of Section 20-15, Addenda and Interpretation.

GENERAL:

1. There is no change to the bid opening date and time.

ON THE CONTRACT SPECIFICATIONS:

1. **INSERT** the following new specifications:
   - **230716 -** HVAC EQUIPMENT INSULATION **(New)**
   - **230900 -** INSTRUMENTATION AND CONTROL **(Substitute)**
   - **233533 -** Exhaust Hood **(New)**
   - **234133** High-Efficiency Particulate Air Filtration **(New)**
   - **238119 -** VARIABLE REFRIGERANT FLOW (VRF) SYSTEM EQUIPMENT **(Substitute)**
   - **238147 -** GEOTHERMAL LOOP FIELD PIPING SYSTEM (CAP TO MECH ROOM) **(New)**

The above specifications were inadvertently omitted from Addendum No. 1.

END OF ADDENDUM

C&S ENGINEERS, INC.

Thomas J. Horth, P.E.
Principal Engineer

SECTION 230716 - HVAC EQUIPMENT INSULATION

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 insulating the following HVAC equipment that is not factory insulated:

1. Expansion/compression tanks.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. 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 removable insulation at equipment connections.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.
5. Detail field application for each equipment type.

1.4 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.

1.5 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.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 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.

1.7 COORDINATION

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

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

    a. Ramco Insulation, Inc.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

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

    a. Ramco Insulation, Inc.

2.3 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.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall 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 50 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E 96/E 96M, 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. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Mon-Eco Industries, Inc.
    e. Vimasco Corporation.

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.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Vimasco Corporation.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. 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).
6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

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, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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

    a. Childers Brand; H. B. Fuller Construction Products.

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, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. 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.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

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

    a. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

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

    a. Foster Brand; H. B. Fuller Construction Products.
    b. Vimasco Corporation.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

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

a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.
d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

a. 3M.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

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. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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

    a. 3M.
    b. Avery Dennison Corporation, Specialty Tapes Division.
    c. Ideal Tape Co., Inc., an American Biltrite Company.
    d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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

    a. Ideal Tape Co., Inc., an American Biltrite Company.

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.

2.12 SECUREMENTS

A. Bands:

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.

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

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

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

1) AGM Industries, Inc.
2) CL WARD & Family Inc.
3) Gemco.
4) Midwest Fasteners, Inc.

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

D. Wire: 0.080-inch nickel-copper alloy.

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

a. C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

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

C. 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.

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

K. 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 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches] [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.

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

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

N. 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.

O. 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.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.7 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

3.8 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heating-hot-water expansion/compression tank insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 1 inch thick.

D. Thermal storage tank (water) insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

END OF SECTION 230716

SECTION 230900 - INSTRUMENTATION AND CONTROL

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. This specification is for reference only. The temperature control system, equipment and labor will be purchased by the owner off of the GSA Schedule 084, PASCO contract number 47QSWA19D000E.

B. Control valves, dampers and flow meters will be furnished to the mechanical contractor for installation.

C. The control system being purchased by the owner will be Alerton supplied by PASCO, Dudley Saunders (315) 488-0262.

D. PASCO will add all new points and graphics to the existing Alerton Compass software.

E. The existing Alerton Control System shall remain in place and operable during and at the completion of this project. If required the Temperature Controls Contractor shall relocate or re-route the required Alerton MSTP cabling as required to maintain system operation.

1.3 DEFINITIONS

A. I/O: Input/output.

B. PID: Proportional plus integral plus derivative.

C. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
    a. Space Temperature: Plus or minus 1 deg F.
    b. Ducted Air Temperature: Plus or minus 1 deg F.
    c. Outside Air Temperature: Plus or minus 2 deg F.
    d. Temperature Differential: Plus or minus 0.25 deg F.
    e. Relative Humidity: Plus or minus 5 percent.

f. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
g. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Controlled Systems:

a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
c. Written description of sequence of operation including schematic diagram.
d. Points list.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.

2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
3. Calibration records and list of set points.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Manufacturers:

1. Alerton Technologies, Inc. distributed by PASCO (Basis of Design)
2. Johnson Controls.; Controls Group
3. Approved Equal

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

2.2 EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
d. Remote communications.
e. Maintenance management.
f. Units of Measure: Inch-pound and SI (metric).

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.

3. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. Response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
1. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
2. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.4 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.Programmable clock is available for applications requiring more than one time clock. Consider using Section 275313 "Clock Systems" as a source for time-programmed on-off commands.

2.5 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.
b. Ebtron, Inc.
c. Heat-Timer Corporation.
d. I.T.M. Instruments Inc.
e. MAMAC Systems, Inc.
f. RDF Corporation.

2. Accuracy: Plus or minus 0.5 deg F at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
5. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 10 sq. ft..
6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Exposed.
b. Set-Point Indication: Exposed.
c. Thermometer: Exposed.
d. Orientation: Horizontal.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Pressure Transmitters/Transducers:

1. Manufacturers:

a. BEC Controls Corporation.
b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0- to 0.25-inch wg.
d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.6 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be furnished by the Electrical contractor and Installed into the duct by the Mechanical contractor. All connections, wiring, etc., to the duct smoke detector shall be by the Electrical contractor.

2.7 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

F. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:

a. BEC Controls Corporation.
b. I.T.M. Instruments Inc.

2.8 THERMOSTATS

A. Temperature Sensors
1. Space sensors
a. Sensors shall be digital type of wound nickel wire, resistance-type element or thermistors with horizontal or vertical case.
b. Mounting height: All room sensors shall be mounted 5’-0” from finished floor to bottom of cover. Coordinate location with adjacent items, such as light switches.
c. Provide digital display, setpoint bias and override switch on space sensors located in offices and conference rooms. Setpoint bias shall be network adjustable from 0°F to +8°F.
d. Provide stainless steel plate temperature sensors in public locations such as vestibules, holding area, lobby, baggage claim, lounge, and security.
e. Provide space sensors to fit in a standard electrical box.
f. Provide accuracy of ±1.0°F.
g. Provide sensors with programmed occupied/unoccupied override button.
2. Duct sensors
a. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
b. Averaging sensors shall be employed in ducts, which are larger than 14 square feet. The averaging tube must contain at least one thermistor for every 3’, with a minimum tube length of 12”.
c. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250°F and 300 series stainless steel for all other applications.
3. Pressure sensors
a. Air pressure measurements in the range of 0” to 10” water column will be accurate to ±1% using a solid-state sensing element.
b. Differential pressure measurements of liquids and gases shall be accurate to ±0.5% of range. The housing shall be NEMA 4 rated.
4. Current and kw sensors

a. Current status switches shall be used to monitor fans, motors, and electrical loads. Current switches shall be available in solid, and split core models and offer either a digital or an analog signal to the automation system.
b. Measurements of 3-phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy use (kWH)

B. Incidental electric thermostats for unit heaters shall be heavy-duty type with concealed adjustment.

C. Electric Low Limit Duct Thermostat:
1. Snap acting, single-pole, single throw, manual reset switch, which trips if the temperature sensed across any 12" of bulb length is equal to or below setpoint.
2. Bulb length: Minimum 20 feet.
3. Provide one thermostat for every HVAC unit.

D. Electric High Limit Duct Thermostat
1. Snap acting, single-pole, single throw, manual reset switch, which trips if the temperature sensed across any 12" of bulb length is equal to or below setpoint.
2. Bulb length: Minimum 20 feet.
3. Provide one thermostat for every HVAC unit."

E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

F. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

G. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

H. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.9 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

    a. Belimo Air Controls (USA), Inc.
    b. Honeywell

2. Dampers: Size for running torque calculated as follows:

    a. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    c. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24 or 120-V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: Minus 22 to plus 122 deg F.
10. Run Time: 12 seconds open, 5 seconds closed.

2.10 DAMPERS

A. Manufacturers:

1. Air Balance Inc.
2. Don Park Inc.; Autodamp Div.

3. Ruskin
4. TAMCO (T. A. Morrison & Co. Inc.).
5. United Enertech Corp.
6. Vent Products Company, Inc.

B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.11 CONTROL VALVES

A. Manufacturers:
1. Honeywell (Basis of Design)
2. Belimo
3. Danfoss

B. DYNAMIC PRESSURE-REGULATING CONTROL VALVES

1. The valve and actuator combination product family shall be a factory assembled and tested unit. All valves and actuators shall be manufactured under ISO 9001 International Quality Control Standards.
2. The valve shall have an integral differential pressure regulator to maintain constant pressure drop across valve seat to decouple valve flow from system pressure changes. Flow control accuracy shall be +/-5% or better. Regulator will be constructed from 316 stainless steel with a rolling diaphragm and operate under positive pressure. Regulator shall be located above axis of pipe with ¼” ISO test port fittings to allow pressure measurement and venting.
3. The actuator shall provide two-position, floating, or proportional control. Proportional control refers to direct acceptance of 2-10 Vdc or a 4-20 mA input signal. Floating control refers to direct acceptance of 24Vac pulse-width modulated open and close commands from a tri-state (SP3T) controller. Two-position control of non-fail safe actuators shall be in the form of 24Vac power controlled by SPDT switch. Two-position control of failsafe actuators shall be in the form of 24Vac power controlled by SPST switch.

4. Basis-of-Design: Honeywell VRN2 / VRW2. Products of other manufacturers will be considered for acceptance provided they equal or exceed the minimum requirements and functional qualities of the specified product. Requests for Architect/Engineer's approval must be accompanied by the "Substitution Request Form", all valves and actuators shall be from the same manufacture, with complete technical data, and the valve manufacture's flow testing documentation from an independently owned third-party testing agency for each valve size and model for evaluation. All materials for evaluation must be received by the Project Manager and Specification Department at least 10 days prior to bid due date. Additional approved manufacturers will be issued by Addendum.
5. Control valves 1/2 to 3 inches: Valves shall be available with female national pipe thread pipe fittings in sizes from ½ up to 3 inches (DN15 to DN80).
    a. Minimum Requirements:
    b. Flow control ball valve shall be individually flow tested at the factory and verified to deviate no more than +/-5% though the minimum to maximum pressure range.
    c. Flow control ball shall have minimum 50:1 rangeability with an equal percentage flow characteristic provided by a laser-milled, glass-filled polymer ball insert. Valve seat seals shall make contact with the ball only, and not the flow control element.
    d. Valve ball and stem construction shall be nickel-plated brass or stainless steel.
    e. Maximum operating differential pressure shall be no less than 35 psid. Close-off pressure shall be 100 psid with ANSI Class IV seat leakage.
    f. Threaded valves bodies shall have static pressure rating of 360 psig (2500 kPa) at 250°F (121 C).
    g. Valve stem assembly shall be of a pack-less design and be field-replaceable without removing the valve body from the piping. Teflon™ seals shall hold the stem in alignment, and protect the O-ring from system temperature fluctuations. Stem O-ring shall be made of peroxide-cured EPDM and be isolated from system treatment chemicals by a reservoir of silicon grease. Valve shall have a blow-out proof stem with minimum 600 psi rating.
    h. Multiple gpm flow ratings shall be available in each valve size, with 26 discrete values available in 1 gpm increments up to 1" and 5 gpm increments up to 3". Intermediate flow settings will be set using mechanical stop in the actuator, or by characterized control signal from the controller.
    i. Actuated valves shall be capable of closing off against their maximum operating differential pressure. Seat leakage when closed shall be ANSI/ASME Class IV, minimum.
    j. Actuators shall be direct coupled rotary type requiring neither crank-arm nor linkage and direct mount to the valve actuator bracket. The bracket shall provide for up to 2 inches (50mm) of pipe insulation.
    k. Actuators shall be capable of operating on 24Vac Class II power, or be UL Recognized or CSA Certified to U.S. and Canadian Standards where used with line voltage.
    l. Actuators shall provide screw terminal wiring connections with adapters for flexible conduit where mechanical protection is required by local codes.
    m. Proportional actuators shall have a rotation direction control switch accessible on the cover to change between proportional or floating control. Actuators that require to be electronically programmed by use of a handheld programming device or external computer software are NOT acceptable.
    n. All actuators shall be designed for a minimum of 60,000 full-stroke cycles at actuator rated torque and temperature, and 1,500,000 repositions.

o. Two-position actuators shall be designed for a minimum of 100,000 full-stroke cycles at rated load and temperature.
p. Actuation shall be available with fail-safe operation capable of returning the valve to a normally open or normally closed position following loss of power.
q. All spring return actuators must be designed for either normally open or normally closed fail-safe operation with a continuously engaged mechanical return spring. This spring must return the actuator to a fail-safe position within 20-25 seconds of power loss.
r. All 5Nm torque, spring return actuators must be able to spring return from -40°F to 150°F.
s. Proportional and floating control actuators shall provide a 2-10 Vdc feedback signal. The signal shall represent the actual flow (gpm) to the associated coil, providing a gpm input to the DDC controller.
t. Actuators shall be available with SPST or SPDT switch for position verification feedback as an available option.

6. Control valves 2 ½ to 6 inches: Valves shall be available with wafer-flanges for use with either ANSI/ASME 125/150 or ANSI/ASME 250/300 pipe flanges in sizes from 2 ½ up to 6 inches (DN65 to DN150). Each wafer flange shall be useable with either of two successive pipe sizes.

a. Minimum Requirements:
1) Flow control valve shall be individually flow tested at the factory and verified to deviate no more than +/-5% though the minimum to maximum pressure range.
2) Flow control valve shall have minimum 50:1 rangeability with an equal percentage flow characteristic provided by a multi-turn, non-rising stem, characterized plug.
3) Valve trim shall be stainless steel.
4) Maximum operating differential pressure rating shall be no less than 58 psid. Close-off pressure shall be 100 psid minimum, at no more than 0.2% leakage.
5) Valve bodies shall have static pressure rating of 580psig (4000kPa) at 248°F (120 C).
6) Valve stem seals shall be EPDM O-rings and be field-replaceable without removing the valve body from the piping.
7) Multiple gpm flow ratings shall be field-selectable in each valve size, with 50 unique settings.
8) Actuated valves shall be capable of closing off against their maximum operating differential pressure. Seat leakage when closed shall be ANSI/ASME Class IV, minimum.
9) Actuators shall be direct coupled six turn rotary type requiring neither crank-arm nor linkage and direct mount to the valve actuator bracket.
10) Actuators shall be capable of operating on 24Vac Class II power, in both electronic fail-safe and stay-in-place configurations. Actuator fail-safe action in the event of power failure shall be field-selectable normally open or normally closed.
11) Actuators shall provide screw terminal wiring connections with adapters for flexible conduit where mechanical protection is required by local codes.

12) Actuators shall have a programming DIP switch accessible under the cover to change between proportional, floating, or pulse width modulation (PWM) control or two-position control through wiring options.
13) Proportional actuators shall have field-adjustable signal zero and span adjustments.
14) Actuation shall be available with electronic fail-safe operation capable of returning the valve to a normally open or normally closed position following loss of power.
15) Proportional and floating control actuators shall provide a 2-10 Vdc feedback signal. The signal shall represent the actual flow (gpm) to the associated coil, providing a gpm input to the DDC controller.

7. General Requirements:

2.12 Valve Schedule: Valve take-off and selection shall be performed and a schedule created by the valve manufacture. Schedule including a separate line for each valve and a column for each of the valve attributes: Valve Identification Tag, Location, Valve Type, Valve Size, Pipe Size, Configuration, Flow Capacity, Minimum Design Pressure Drop, Maximum Pressure Drop, Fail Position, Close-off Pressure, Actuator Identification Tag, and Actuator Type. The valve manufacture's authorized distributor shall either, directly prepare the valve with actuator combination submittal or review and approve the submittal prepared by the contractor prior to submission for Architect/Engineer's approval.

2.13 Valves shall not be installed with stems below the horizontal plane to prevent actuator damage due to stem seal leakage, or accumulation of particulate in the stem packing.

2.14 Valves shall be capable for use only in cold, warm, and hot water system applications with diethylene glycol, ethylene glycol, or propylene glycol solutions up to 50% concentration.

2.15 A water filtration and treatment system shall be installed and operated according to the requirements of Division 23 25 13, Water Treatment for Closed-Loop Hydronic Systems. These requirements shall meet or exceed European Norm VDI 2035. The presence of excess rust in the system will void the manufacturer's warranty.

2.16 Run time shall be constant and independent of: load, temperature, and supply voltage (within specifications).

2.17 Accessories Identification tags shall be available for all valves; tags shall be indelibly marked with gpm, model number, and tag location.

A. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:

a. Two Position: Line size.
b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

B. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer.
2. Disc Type: Nickel-plated ductile iron.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

C. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

D. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Thermostatic Operator: Liquid-filled integral sensor with integral adjustable dial.

2.18 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units.

B. Verify that ductwork and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install control units and operators. Implement all features as required to achieve sequence of operation.

B. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

C. Provide stainless steel plate type sensors in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

D. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

G. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

H. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. ALL control and interlock wiring shall comply with the national and local electrical codes and Division 26 of these specifications and shall be the responsibility of the controls contractor. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.

B. All Class 1 (line voltage) wiring shall be UL listed and run in approved raceway in accordance with NEC and Division 26 requirements.

C. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

2. All cables shall be UL listed for application, i.e. cables used in ceiling plenums shall be UL listed specifically for that purpose. Where plenum cables are used without raceways, they shall be supported from or anchored to structural members.

3. Except in ceiling plenums, all exposed control wiring shall be run in conduits.

D. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

E. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result.

F. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

G. Contractor shall provide step down transformers, as needed.

H. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

I. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

J. Size of conduit and gauge and type of wire shall be the design responsibility of this Contractor, in keeping with the manufacturer's recommendation and NEC.

1. Conduits are required for control wiring runs located in walls.

K. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

L. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

M. Adhere to Division 26 requirements for installation of raceway.

N. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

O. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

D. All control wiring to be labeled within 2 inches of each termination with a tag that complies with the naming convention specified in 2.2/F/2 of this Section.

E. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

F. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

H. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

I. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

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

   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.

C. Control System Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check system as follows:

    a. Verify that controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.

e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

6. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

7. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
8. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
9. Provide diagnostic and test instruments for calibration and adjustment of system.
10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three 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 HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training."

3.7 SEQUENCE OF OPERATIONS:

A. Geothermal-Source Heat Pumps
1. Occupied Mode
a. The BAS shall index the water source heat pump into the occupied mode by pressing override on space sensor or from the operator workstation with time schedule or manual command. Once in the occupied mode the fan will run continuously and the compressor will cycle to maintain occupied space heating and cooling set points.
2. Unoccupied Mode
a. Once in the unoccupied mode the fan and the compressor will cycle from the space sensor to maintain unoccupied space heating and cooling set points.

b. Monitored or controlled points (typical for each of heat pump):

Point Name	Type
Space Temperature	AI
Space Bias	AI
Discharge Air Temperature	AI
Leaving Water Temperature	AI
Unit General Alarm	BI
Fan Command	BO
Heating Command	BO
Cooling Command	BO
General Alarm Reset	BO
Tenent Override Reset	BO

B. Geothermal Loop Pumps (P1 & P2):

1. Pump Control:

1. Lead pump will ramp up and shall continue to ramp up to maintain loop differential pressure between the supply and return as measured 2/3rds out in system piping. If the lead pump is not able to maintain loop differential pressure set point, the lag pump shall enable and ramp up to maintain loop differential pressure. An alarm will be recorded at operator workstation. The BAS will monitor the status of each pump. The status from each pump will be used to equalized runtime. Each pump shall run for an adjustable length of time, before the other pump takes over and shall run for equal length of time.

2. Sequencing pumps will be based on the flow requirements of heat pumps in operation. Each heat pump will have a water valve that will be closed when its compressor is not in operation. When the compressor is required to operate, its associated water valve shall open before the compressor operates.

3. Monitored or controlled points:

Point Name	Type
Pump P-1 Command	BO
Pump P-1 Signal	AO
Pump P-1 Status	BI

Pump P-1 VFD Alarm	BI
Pump P-1 Runtime	AI
Pump P-2 Command	BO
Pump P-2 Signal	AO
Pump P-2 Status	BI
Pump P-2 VFD Alarm	BI
Pump P-2 Runtime	AI
Loop Differential Pressure	AI

2. Geothermal Temperature Loop Control
   a. Occupied Mode/Unoccupied:
      1) The loop water temperature shall be maintained to be between 40-90deg.F. for system operation.

   b. Alarms
      1) The loop controller shall provide an alarm and emergency shutdown signal as follows:
         a) Alarm if loop temperature rises to 90deg.F., shutdown at 100deg.F. (high limit).
         b) Alarm if loop temperature falls to 30deg.F., shutdown at 20deg.F. (low limit)
         c) Alarm and shutdown for lack of loop water flow.

C. Energy Recovery Ventilator(s) – ERV-1 & ERV-2
   1. A field supplied and installed DDC controller will be wired to the ERV to enable/disable the ERV's. During the occupied mode the supply and exhaust fan shall run continuously. The Manufacturer will provide preprogrammed controls for defrost mode, etc.
   2. A freeze stat and discharge air sensor will provide for an alarm and duct temperature indication.
   3. A current sensor shall be installed to report run status of the unit.
   4. When either ERV units are enabled the DDC controller shall open both the Outside Air and Exhaust dampers at the building envelope. If both ERV units are not running the DDC controller will close both the Outside and Exhaust Air Dampers.

D. Split System air Conditioners (CRAC-1):
   1. The cooling shall be controlled thru the factory provided 7 day programmable thermostat. The fan shall run only when cooling/heating is enabled to maintain space temperature (adj.) and humidity (adj.). The thermostat shall cycle cooling to maintain space temperature of 75degF (adjustable).
   2. BACnet Integration, the CRAC unit is to be furnished with BACnet IP card for integration by the Temperature Controls Contractor.

E. Exhaust Hood Fans (F-1,2)
   1. Hood Exhaust Fans will be manually controlled by a wall switch.

F. Paddle Fans (PF-1,2)
   1. Paddle Fans will be manually controlled by a wall speed controller.

G. Electric Wall Heaters
   1. Electric Wall Heaters will be controlled off an integral thermostat furnished and installed by the manufacturer.

H. Electric Duct Heaters
   1. EDH-1: A field installed DDC controller shall stage the electric duct heater to maintain a discharge air temperature of 45°F adj.
   2. EDH-2,3,4: Electric Duct heaters will be controlled off of relay boards furnished by the VRF manufacturer.

I. VRF Systems (DS 2-11, VRF 1,2 BS-1,2)
   1. The VRF system will be supplied with wall controllers, thermostats and (1) BACnet/IP gateway. The DDC contractor will install the wall controllers and thermostats as well as wire all units back to the BACnet/IP gateway. The DDC contractor will require assistance from the manufacturers' rep during start up for a list of BACnet objects to integrate to.

END OF SECTION 230900

SECTION 233533 – Exhaust Hood

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. Exhaust hoods

1.3 ACTION SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's data and installation instructions for each type of fume hood. Provide data indicating compliance with ASHRAE Standard 110.1995.

B. Samples: Samples if called for will be reviewed for color, texture, and pattern only. Submit the following:

   a. Hood interior lining, 6 by 6 inches.

   b. Hood enclosure, 6 by 6 inches, of color selected.

   c. Operation sign(s).

   d. Shop Drawings: Submit shop drawings for fume hoods showing plans, elevations, ends, cross-sections, service run spaces, location and type of service fittings:

   1) Coordinate shop drawings with other work involved.

   2) Provide roughing-in drawings for mechanical and electrical services when required.

   3) Provide face opening, air volume, and static pressure drop data.

C. Shop Drawings: For listed exhaust hoods.

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Detail fabrication and assembly of hangers and seismic restraints.

D. Non-Specified Manufacturer's Samples:

1. A sample from each non-specified manufacturer will be required and reviewed per specification. This sample shall be delivered, at no cost to the architect or owner to a destination set forth by the architect or owner. The sample must then be tested per section 1.4.C by an independent test agency hired by the submitting company and approved by the owner/architect. A passing test and owner/architect approval of the prototype must be written and approved seven (7) days before quotation deadline as a condition of acceptance for any quotation participant.

1.4 STANDARD FUME HOOD PERFORMANCE REQUIREMENTS

A. Fume hoods shall be of complete airfoil design to insure maximum operating efficiency. Foil sections at the front of the hood shall minimize eddying of air currents at the hood face and the rear baffle system shall minimize turbulence in the upper portion of the hood interior.

B. Standard Fume Hood Types
1. Open Bypass: The hoods shall be of the bypass type. The fume hood design shall allow for automatic air bypass above the sash opening. The bypass shall limit the maximum air velocity through the face of the hood and provide for a constant volume of air through the hood regardless of sash position. The bypass shall control the increase in face velocity as the sash is lowered to limit the maximum velocity to not more than three and one-half, times the velocity with the sash full open.

C. Containment
1. Purpose: The purpose of this specification is to prequalify the performance of the bidder's laboratory fume hood before award of contract. At his option, the owner or his representative may require the same tests to be performed and the same performance be achieved before acceptance of the hood after award of contract. The owner or his representative shall witness the tests. Failure to meet the performance specified shall be cause for rejection of the bidder.
2. Test Method: The hood shall be tested per the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 110-1995.
3. Instrumentation, Equipment and Test Personnel: Qualified personnel to perform the tests shall be supplied by the bidder. Instrumentation and equipment required shall be supplied by the bidder at his expense. Required instrumentation shall include but not be limited to the following items:
    a. Thermal anemometer capable of measuring air velocities from 10 to 600 ft./minute
    b. Three dozen one-half minute smoke candles
    c. Four ounces of Titanium Tetrachloride
    d. Supply of cotton throat swabs
    e. ITI Leakmeter 120 calibrated to indicate concentration of sulfur hexafluoride or equivalent
    f. Flowmeter – 150 ml/minute capacity
    g. Flowmeter – 15 L/minute capacity
    h. Four gas sampling bags – 8 liter capacity
    i. Two vacuum pumps – 1 CFM capacity
    j. Two flow regulating valves
    k. Two size 3 tanks of sulfur hexafluoride with a two-stage regulator or other tracer gas suitable for detector to be used
    l. Three-way gas valve

m. Mannequin, 5’7” in height, or reasonable human proportions with arms hanging at its side
n. ASHRAE 110-1995 tracer gas ejector

4. ASHRAE Standard 110-1995 Test: Hood shall be tested with a face velocity of 100 FPM full open vertically and at 100 FPM right, left and center 100% open horizontally. If horizontal openings are present, additional sash configurations and face velocities may be specified. The hood shall have a performance rating of 4.0 AM 0.01 or better wherein:
   a. 4.0 = tracer gas release in liters/minute
   b. AM = as manufactured
   c. 0.01 = level of control of tracer gas in parts per million (ppm).

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in listed grease ducts and field-fabricated grease ducts.

B. The laboratory fume hood manufacturer shall provide fume hood work tops and casework all manufactured or shipped from the same geographic location to assure proper staging, shipment and single source responsibility.

1.7 RELATED PUBLICATIONS

A. ASHRAE Standard 110.1995 - Method of Testing Performance of Laboratory Fume Hoods

B. NSF STD#49 – Photometric Method of Testing

C. NIH03-112C - National Institute of Health Specification

D. UL – Underwriters Laboratories

E. ASTM D552 – Bending Test

F. NFPA-45 – National Fire Protection Association

1.8 BASIS OF WORK

A. It is the intent of this specification to use Kewaunee Scientific Corporation, Statesville, North Carolina, as the standard of construction for laboratory fume hoods. The construction standards of the Kewaunee Supreme Air product line shall provide the basis for quality and functional installation.

B. Supply all equipment in accordance with this specification. The offering of a product differing in materials and construction from this specification requires written approval. This approval must be obtained seven (7) days before the proposal deadline. Procedures for obtaining approval for an alternate manufacturer are defined in section 2.00 C. in this specification.

C. The owner/architect reserves the right to reject qualified or alternate proposals and to award based on product value where such action assures the owner greater integrity of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The basis of this specification is the Supreme Air fume hood as manufactured by Kewaunee Scientific Corporation
   1. An equal product must be approved by an engineer.

B. All laboratory equipment covered by the specification shall be the product of one manufacturer and be fabricated at one geographic location to assure shipping continuity and single-source responsibility. All quotations from a manufacturer other than Kewaunee Scientific shall contain a review of the following capabilities:
   1. List of shop facilities
   2. List of engineering and manufacturing personnel
   3. Proof of financial ability to fulfill the contract
   4. List of a minimum of ten installations over the last five years of comparable scope
   5. Proof of project management and installation capabilities

C. The selected manufacturer must warrant for a period of one-year starting (date of acceptance or occupancy, whichever comes first) that all products sold under the contract referenced above shall be free from defects in material and workmanship. Purchaser shall notify the manufacturer’s representative immediately of any defective product. The manufacturer shall have a reasonable opportunity to inspect the goods. The purchaser shall return no product until receipt by purchaser of written shipping instructions from the manufacturer.

2.2 MATERIALS AND CONSTRUCTION

A. Fume Hood Superstructure Frame: A free-standing rigid frame structure of steel angle shall be provided to support exterior panels and interior liner and baffle panels. To allow for maintenance and replacements, the interior liner panels shall be removable without disassembly of the frame structure and outer steel panels. Likewise, the exterior steel panels shall be removable without disassembly of the frame structure and inner liner panels. Fume hoods that require disassembly of the superstructure for liner replacement are not acceptable.

B. Fume Hood Interior Walls: Double wall ends, not more than 4” wide, shall be provided to maximize interior working area. The area between the double wall ends shall be closed to house the remote control valves. The front vertical facia section shall have a full 135 degree 1” radius at the front leading edge to provide a streamlined section and insure smooth even flow of air into the hood. The vertical facias shall contain the required service controls, electrical switches

and receptacles. The hood interior end panels and sash track shall be flush with the facia to prevent eddy currents and back flow of air.

C. Fume Hood Airfoil: A streamlined airfoil shall be integral at the bottom of the hood opening on bench and distillation hoods. This foil shall provide a nominal 1” open space between the foil and the top front edge of the work surface to direct an air stream across the work surface to prevent back flow of air. The airfoil shall extend back under the sash, so that the sash does not close the 1” opening. The foil shall be removable to allow large equipment into the hood. The foil shall be of 12-gauge steel to resist denting and flexing. Walk-in hoods shall have a stop located at the bottom of the sash track that will ensure a nominal 1” opening between the bottom of the sash and the floor.

D. Access Opening: The interior end liner panels shall be furnished with an opening that provides access to the service piping and valves to facilitate installation and maintenance. The openings shall be covered with a removable panel with rounded corners. Panels that require tools to remove are not acceptable. The panel shall provide an overlapping seal on all edges.

E. Fume Hood Finish: After the component parts have been completely welded together and before finishing, they shall be given a pre-paint treatment to provide excellent adhesion of the finish system to the steel and to aid in the prevention of corrosion. Physical and chemical cleaning of the steel shall be accomplished by washing with an alkaline cleaner, followed by a spray treatment with a complex metallic phosphate solution to provide a uniform fine grained crystalline phosphate surface that shall provide both an excellent bond for the finish and enhance the protection provided by the finish against humidity and corrosive chemicals. After the phosphate treatment, the steel shall be dried and all steel surfaces shall be coated with a chemical and corrosion-resistant, environmentally friendly, electrostatically applied powder coat finish. All components shall be individually painted, insuring that no area be vulnerable to corrosion due to lack of paint coverage. The coating shall then be cured by baking at elevated temperatures to provide maximum properties of corrosion and wear resistance.

F. Fume Hood Dimensions: Double wall end panel thickness shall not exceed 4”. Interior clear working height shall be not less than 41-3/4” at any location in the interior of the hood on bench hoods and 76” on walk-in and distillation hoods. Interior depth from the back of the sash to the front of the rear baffle shall not be less than 25-1/4”. The sash opening shall be not less than 28” in height above the worksurface on bench hoods.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Preparation: Prior to beginning installation of fume hood, check and verify that no irregularities exist that would affect quality of execution of work specified.

B. Coordination: Coordinate the work of the Section with the schedule and other requirements of other work being performed in the area at the same time both with regard to mechanical and electrical connections to and in the fume hoods and the general construction work.

C. Performance: Install fume hoods, plumb, level, rigid, securely anchored to building and adjacent furniture in proper location, in accordance with manufacturer's instructions and the approved shop drawings. Provide filler panels between top of hood and ceiling. Securely attach access panels but provide for easy removal and secure reattachment. Do not install any damaged units.

D. Adjust and Clean:
   1. After installations are complete, adjust all moving parts for smooth operation.
   2. Remove all packing materials and debris resulting from this work, and turn over the fume hoods to the Owner clean and polished both inside and out.
   3. Repair or remove and replace defective work, as directed by owner and/or his representative upon completion of installation.

E. Protection:
   1. Provide reasonable protective measures to prevent casework and equipment from being exposed to other construction activity.
   2. Advise owner and/or his representative of procedures and precautions for protection of material, installed laboratory casework and fixtures from damage by work of other trades.

END OF SECTION 233533

SECTION 234133 - HIGH-EFFICIENCY PARTICULATE AIR FILTRATION

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. HEPA rigid-cell box filters.
2. HEPA V-bank cell filters.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for HEPA filters.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate.

B. HEPA: High-efficiency particulate air.

C. PAO: Poly-alpha-olefin.

D. PSL: Polystyrene latex.

E. ULPA: Ultralow penetration air.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, 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.

B. Product Test Reports: For each filter, for tests performed by a qualified testing agency.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.7 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. Provide two complete sets of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean, dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.

2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.0.

B. ASHRAE 62.1 Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

C. Comply with NFPA 90A and NFPA 90B.

D. Comply with UL 900.

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

2.2 HEPA RIGID-CELL BOX FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow and with holding frames.

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. AAF International.
b. AirGuard; Clarcor Air Filtration Products, Inc.
c. Air-Nu.
d. Camfil Farr.
e. Flanders Corporation.
f. Glasfloss Industries.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

D. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None.
2. Media to Filter Frame Seal Material: Polyurethane.
3. Faceguard Material: Match corresponding duct material.
4. Faceguard Location: Upstream.

E. Filter-Media Frames:

1. Material: Aluminum.
2. Filter Frame to Mounting Frame Seal Material: Neoprene.
3. Filter Frame to Mounting Frame Seal Location: Upstream.
4. Style: Box.

2.3 HEPA V-BANK CELL FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media at an angle to airflow and with holding frames.

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. AAF International.
b. Camfil Farr.
c. Flanders Corporation.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

D. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None.
2. Media to Filter Frame Seal Material: Polyurethane.

E. Filter-Media Frames:

1. Material: Aluminum.
2. Filter Frame to Mounting Frame Seal Material: Neoprene.
3. Filter Frame to Mounting Frame Seal Location: Upstream.

4. Style: Box.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF FILTERS

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.

D. Coordinate filter installations with duct and air-handling unit installations.

3.3 INSTALLATION OF HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections.

E. Tests and Inspections:

1. HEPA and ULPA Filters: Pressurize housing to a minimum of 6.0-inch wg, and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME AG-1.

F. Air filter will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

3.7 PROTECTION

A. Protect installed products and accessories from damage during construction.

END OF SECTION 234133

SECTION 238119 - VARIABLE REFRIGERANT FLOW (VRF) SYSTEM EQUIPMENT

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. DS Concealed Unit
2. VRF Heat Pump
3. Branch Selector Box
4. Indoor, Energy Recovery Ventilator

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

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 diagrams for power, signal, and control wiring.

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 VRF Ducted Concealed/VRF Ceiling Suspended 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. Access panels.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF ducted concealed unit, VRF ceiling suspended unit, outdoor condensing units, and branch selector boxes include emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," 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. Ducted Concealed Units: Furnish one spare filter 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."

1.8 COORDINATION

A. Coordinate layout and installation of VRF ducted concealed units/ceiling suspended unit 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: 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.

2. Warranty Period (Parts Only): Ten years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED SPLIT UNIT

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

a. Daikin
b. Mitsubishi Electric
c. LG
d. Samsung

B. Ducted Split Concealed Unit Arrangement: Horizontal Discharge.

C. Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

D. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

E. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Connection: Steel flange connection.
2. Return-Air Connection: Steel flange connection.
3. Cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV 13) according to ASHRAE 52.2 and all addendums.

G. Indoor Refrigerant Coils: Copper tube with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

H. Direct-Driven Fans: Direct-drive DC (ECM), statically and dynamically balanced impeller; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Control devices and operational sequence are specified in Section 230548 "Vibration Controls for HVAC Piping and Equipment."

J. Basic Unit Controls:

1. Control voltage transformer.
2. The unit shall have controls provided by manufacturer to perform input functions necessary to operate the system.
3. Provide an “in-room” sensor for rooms not being controlled by unit’s main thermostat.
4. Wall-mounting thermostat with the following features.

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Automatic changeover.
    d. Exposed set point.
    e. Degree F indication.
    f. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    g. Output data includes room temperature and humidity, supply-air temperature, operating mode, and status.
5. The unit shall be compatible with an advanced web-based multi-zone controller. The web-based controller must have the capabilities for owner or building manager to monitor system.

6. Refrigerant-Coil Operation:

    a. Occupied Periods: Start compressor to maintain room temperature.
    b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.

7. Supplemental Heating-Coil Operation:

    a. Occupied Periods: Energize electric-resistance coil to provide heating if outdoor temperature falls below 10 deg F.
    b. Unoccupied Periods: Energize electric-resistance coil if room temperature falls below setback temperature.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

L. Capacities and Characteristics: (AS SCHEDULED)

2.3 HEAT PUMP

A. Manufacturers: The condensing unit is designed specifically for use with the ceiling suspended units by same manufacturer.

   a. Daikin
   b. Mitsubishi Electric
   c. LG
   d. Samsung
   e. Aston

B. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

C. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

   1. Shall be completely weatherproof and corrosion resistant.
   2. Shall be constructed from rust-proof mild steel panels.

D. Condensing Coil: Copper tubes with corrosion-resistant coating, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

E. Corrosion-Resistant Coating:

   1. Fins shall be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.

F. Direct-Driven Fans: Direct-drive DC, propeller type fans; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

   1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

G. Electrical Connection: Factory wire motors and controls.

H. Capacities and Characteristics: (AS SCHEDULED)

2.4 BRANCH SELECTOR BOX

A. Manufacturers: The branch selector box unit is designed specifically for use with the ducted concealed units by same manufacturer

   a. Daikin
   b. Mitsubishi Electric
   c. LG
   d. Samsung

B. Branch Selector Arrangement: Suspended from ceiling/roof structure.

C. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

D. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

E. Basic Unit Controls:

1. Control voltage transformer.

F. Electrical Connection: Factory wire motors and controls for a single electrical connection.

G. Capacities and Characteristics: (AS SCHEDULED)

2.5 INDOOR, ENERGY RECOVERY VENTILATOR

A. Description: Factory-assembled and -tested complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Damper Assemblies:

1. Outdoor Air Intake and Exhaust Air Discharge:

a. Low-leakage damper with spring return electric actuator to fail closed on loss of power.
b. Damper controlled by unit to open when unit is operating and close when unit off.

D. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.

1. Fan(s):

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
c. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

E. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.

1. Access: To accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.
3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

F. Energy Recovery Heat Exchanger:

1. Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
2. Fixed element with no moving parts.
3. AHRI 1060 certified and bearing the AHRI labe1.

G. Unit Controls:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit entering outdoor air temperature.
    b. Unit leaving supply air temperature.
    c. Unit entering exhaust air temperature.
    d. Unit leaving exhaust air temperature.

4. Field-Customizable I/O Capability:

    a. Analog Inputs: Three for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, local auto operation mode, manual operation mode, filter service notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

I. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units 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 ducted concealed/ceiling suspended units level and plumb.

B. Install ducted concealed/ceiling suspended units to comply with NFPA 90A.

C. Suspend ducted concealed/ceiling suspended units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration Controls for HVAC Piping and Equipment."

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

E. Install new filters in each ducted concealed unit within two weeks after Substantial Completion.

F. Provide control/transmission wiring from unit to remote controller.

3.3 CONCRETE EQUIPMENT BASES

A. Minimum Compressive Strength of 4000 psi at 28 days. Nominal maximum aggregate size of 1-1/2-inch Plain-Steel Welded-Wire Reinforcement.

B. Brush finish with chamfer edges. Nominal 4 inches high pad. Coordinate pad size with size of equipment. Provide dowels and inserts required for equipment mounting prior to pouring concrete.

3.4 CONNECTIONS

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

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to ducted concealed/ceiling suspended unit factory refrigerant piping package. Install piping package if shipped loose.
3. Connect condensate drain to condensate Schedule 40 PVC piping.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

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

3.5 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. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. 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.

3.6 ADJUSTING

A. Adjust initial temperature 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.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train owner's maintenance personnel to adjust, operate, and maintain all VRF system equipment.

END OF SECTION 238219

SECTION 230716 - HVAC EQUIPMENT INSULATION

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 insulating the following HVAC equipment that is not factory insulated:

1. Expansion/compression tanks.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. 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 removable insulation at equipment connections.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.
5. Detail field application for each equipment type.

1.4 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.

1.5 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.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 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.

1.7 COORDINATION

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

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

    a. Ramco Insulation, Inc.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

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

    a. Ramco Insulation, Inc.

2.3 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.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall 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 50 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Vimasco Corporation.

2. Water-Vapor Permeance: ASTM E 96/E 96M, 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. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Mon-Eco Industries, Inc.
    e. Vimasco Corporation.

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.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Vimasco Corporation.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. 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).
6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

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

    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Mon-Eco Industries, Inc.

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, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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

    a. Childers Brand; H. B. Fuller Construction Products.

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, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. 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.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering equipment.

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

    a. Childers Brand; H. B. Fuller Construction Products.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

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

    a. Foster Brand; H. B. Fuller Construction Products.
    b. Vimasco Corporation.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

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

a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Johns Manville; a Berkshire Hathaway company.
b. P.I.C. Plastics, Inc.
c. Proto Corporation.
d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

a. 3M.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

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. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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

    a. 3M.
    b. Avery Dennison Corporation, Specialty Tapes Division.
    c. Ideal Tape Co., Inc., an American Biltrite Company.
    d. Knauf Insulation.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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

    a. Ideal Tape Co., Inc., an American Biltrite Company.

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.

2.12 SECUREMENTS

A. Bands:

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

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.

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

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.
4) Nelson Stud Welding.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

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

1) AGM Industries, Inc.
2) CL WARD & Family Inc.
3) Gemco.
4) Midwest Fasteners, Inc.

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

D. Wire: 0.080-inch nickel-copper alloy.

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

a. C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

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

C. 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.

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

K. 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 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches] [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.

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

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

N. 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.

O. 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.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.7 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

3.8 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heating-hot-water expansion/compression tank insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 1 inch thick.

D. Thermal storage tank (water) insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

END OF SECTION 230716

SECTION 230900 - INSTRUMENTATION AND CONTROL

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. This specification is for reference only. The temperature control system, equipment and labor will be purchased by the owner off of the GSA Schedule 084, PASCO contract number 47QSWA19D000E.

B. Control valves, dampers and flow meters will be furnished to the mechanical contractor for installation.

C. The control system being purchased by the owner will be Alerton supplied by PASCO, Dudley Saunders (315) 488-0262.

D. PASCO will add all new points and graphics to the existing Alerton Compass software.

E. The existing Alerton Control System shall remain in place and operable during and at the completion of this project. If required the Temperature Controls Contractor shall relocate or re-route the required Alerton MSTP cabling as required to maintain system operation.

1.3 DEFINITIONS

A. I/O: Input/output.

B. PID: Proportional plus integral plus derivative.

C. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
    a. Space Temperature: Plus or minus 1 deg F.
    b. Ducted Air Temperature: Plus or minus 1 deg F.
    c. Outside Air Temperature: Plus or minus 2 deg F.
    d. Temperature Differential: Plus or minus 0.25 deg F.
    e. Relative Humidity: Plus or minus 5 percent.

f. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
g. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Controlled Systems:

a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
c. Written description of sequence of operation including schematic diagram.
d. Points list.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.

2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
3. Calibration records and list of set points.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Manufacturers:

1. Alerton Technologies, Inc. distributed by PASCO (Basis of Design)
2. Johnson Controls.; Controls Group
3. Approved Equal

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

2.2 EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
d. Remote communications.
e. Maintenance management.
f. Units of Measure: Inch-pound and SI (metric).

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.

3. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. Response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
1. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
2. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.4 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.Programmable clock is available for applications requiring more than one time clock. Consider using Section 275313 "Clock Systems" as a source for time-programmed on-off commands.

2.5 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:

a. BEC Controls Corporation.
b. Ebtron, Inc.
c. Heat-Timer Corporation.
d. I.T.M. Instruments Inc.
e. MAMAC Systems, Inc.
f. RDF Corporation.

2. Accuracy: Plus or minus 0.5 deg F at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
5. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 10 sq. ft..
6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Exposed.
b. Set-Point Indication: Exposed.
c. Thermometer: Exposed.
d. Orientation: Horizontal.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Pressure Transmitters/Transducers:

1. Manufacturers:

a. BEC Controls Corporation.
b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0- to 0.25-inch wg.
d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.6 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be furnished by the Electrical contractor and Installed into the duct by the Mechanical contractor. All connections, wiring, etc., to the duct smoke detector shall be by the Electrical contractor.

2.7 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

F. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:

a. BEC Controls Corporation.
b. I.T.M. Instruments Inc.

2.8 THERMOSTATS

A. Temperature Sensors
1. Space sensors
a. Sensors shall be digital type of wound nickel wire, resistance-type element or thermistors with horizontal or vertical case.
b. Mounting height: All room sensors shall be mounted 5’-0” from finished floor to bottom of cover. Coordinate location with adjacent items, such as light switches.
c. Provide digital display, setpoint bias and override switch on space sensors located in offices and conference rooms. Setpoint bias shall be network adjustable from 0°F to +8°F.
d. Provide stainless steel plate temperature sensors in public locations such as vestibules, holding area, lobby, baggage claim, lounge, and security.
e. Provide space sensors to fit in a standard electrical box.
f. Provide accuracy of ±1.0°F.
g. Provide sensors with programmed occupied/unoccupied override button.
2. Duct sensors
a. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
b. Averaging sensors shall be employed in ducts, which are larger than 14 square feet. The averaging tube must contain at least one thermistor for every 3’, with a minimum tube length of 12”.
c. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250°F and 300 series stainless steel for all other applications.
3. Pressure sensors
a. Air pressure measurements in the range of 0” to 10” water column will be accurate to ±1% using a solid-state sensing element.
b. Differential pressure measurements of liquids and gases shall be accurate to ±0.5% of range. The housing shall be NEMA 4 rated.
4. Current and kw sensors

a. Current status switches shall be used to monitor fans, motors, and electrical loads. Current switches shall be available in solid, and split core models and offer either a digital or an analog signal to the automation system.
b. Measurements of 3-phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy use (kWH)

B. Incidental electric thermostats for unit heaters shall be heavy-duty type with concealed adjustment.

C. Electric Low Limit Duct Thermostat:
1. Snap acting, single-pole, single throw, manual reset switch, which trips if the temperature sensed across any 12" of bulb length is equal to or below setpoint.
2. Bulb length: Minimum 20 feet.
3. Provide one thermostat for every HVAC unit.

D. Electric High Limit Duct Thermostat
1. Snap acting, single-pole, single throw, manual reset switch, which trips if the temperature sensed across any 12" of bulb length is equal to or below setpoint.
2. Bulb length: Minimum 20 feet.
3. Provide one thermostat for every HVAC unit."

E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

F. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

G. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

H. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.9 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

    a. Belimo Air Controls (USA), Inc.
    b. Honeywell

2. Dampers: Size for running torque calculated as follows:

    a. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
    c. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24 or 120-V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: Minus 22 to plus 122 deg F.
10. Run Time: 12 seconds open, 5 seconds closed.

2.10 DAMPERS

A. Manufacturers:

1. Air Balance Inc.
2. Don Park Inc.; Autodamp Div.

3. Ruskin
4. TAMCO (T. A. Morrison & Co. Inc.).
5. United Enertech Corp.
6. Vent Products Company, Inc.

B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.11 CONTROL VALVES

A. Manufacturers:
1. Honeywell (Basis of Design)
2. Belimo
3. Danfoss

B. DYNAMIC PRESSURE-REGULATING CONTROL VALVES

1. The valve and actuator combination product family shall be a factory assembled and tested unit. All valves and actuators shall be manufactured under ISO 9001 International Quality Control Standards.
2. The valve shall have an integral differential pressure regulator to maintain constant pressure drop across valve seat to decouple valve flow from system pressure changes. Flow control accuracy shall be +/-5% or better. Regulator will be constructed from 316 stainless steel with a rolling diaphragm and operate under positive pressure. Regulator shall be located above axis of pipe with ¼” ISO test port fittings to allow pressure measurement and venting.
3. The actuator shall provide two-position, floating, or proportional control. Proportional control refers to direct acceptance of 2-10 Vdc or a 4-20 mA input signal. Floating control refers to direct acceptance of 24Vac pulse-width modulated open and close commands from a tri-state (SP3T) controller. Two-position control of non-fail safe actuators shall be in the form of 24Vac power controlled by SPDT switch. Two-position control of failsafe actuators shall be in the form of 24Vac power controlled by SPST switch.

4. Basis-of-Design: Honeywell VRN2 / VRW2. Products of other manufacturers will be considered for acceptance provided they equal or exceed the minimum requirements and functional qualities of the specified product. Requests for Architect/Engineer's approval must be accompanied by the "Substitution Request Form", all valves and actuators shall be from the same manufacture, with complete technical data, and the valve manufacture's flow testing documentation from an independently owned third-party testing agency for each valve size and model for evaluation. All materials for evaluation must be received by the Project Manager and Specification Department at least 10 days prior to bid due date. Additional approved manufacturers will be issued by Addendum.
5. Control valves 1/2 to 3 inches: Valves shall be available with female national pipe thread pipe fittings in sizes from ½ up to 3 inches (DN15 to DN80).
    a. Minimum Requirements:
    b. Flow control ball valve shall be individually flow tested at the factory and verified to deviate no more than +/-5% though the minimum to maximum pressure range.
    c. Flow control ball shall have minimum 50:1 rangeability with an equal percentage flow characteristic provided by a laser-milled, glass-filled polymer ball insert. Valve seat seals shall make contact with the ball only, and not the flow control element.
    d. Valve ball and stem construction shall be nickel-plated brass or stainless steel.
    e. Maximum operating differential pressure shall be no less than 35 psid. Close-off pressure shall be 100 psid with ANSI Class IV seat leakage.
    f. Threaded valves bodies shall have static pressure rating of 360 psig (2500 kPa) at 250°F (121 C).
    g. Valve stem assembly shall be of a pack-less design and be field-replaceable without removing the valve body from the piping. Teflon™ seals shall hold the stem in alignment, and protect the O-ring from system temperature fluctuations. Stem O-ring shall be made of peroxide-cured EPDM and be isolated from system treatment chemicals by a reservoir of silicon grease. Valve shall have a blow-out proof stem with minimum 600 psi rating.
    h. Multiple gpm flow ratings shall be available in each valve size, with 26 discrete values available in 1 gpm increments up to 1" and 5 gpm increments up to 3". Intermediate flow settings will be set using mechanical stop in the actuator, or by characterized control signal from the controller.
    i. Actuated valves shall be capable of closing off against their maximum operating differential pressure. Seat leakage when closed shall be ANSI/ASME Class IV, minimum.
    j. Actuators shall be direct coupled rotary type requiring neither crank-arm nor linkage and direct mount to the valve actuator bracket. The bracket shall provide for up to 2 inches (50mm) of pipe insulation.
    k. Actuators shall be capable of operating on 24Vac Class II power, or be UL Recognized or CSA Certified to U.S. and Canadian Standards where used with line voltage.
    l. Actuators shall provide screw terminal wiring connections with adapters for flexible conduit where mechanical protection is required by local codes.
    m. Proportional actuators shall have a rotation direction control switch accessible on the cover to change between proportional or floating control. Actuators that require to be electronically programmed by use of a handheld programming device or external computer software are NOT acceptable.
    n. All actuators shall be designed for a minimum of 60,000 full-stroke cycles at actuator rated torque and temperature, and 1,500,000 repositions.

o. Two-position actuators shall be designed for a minimum of 100,000 full-stroke cycles at rated load and temperature.
p. Actuation shall be available with fail-safe operation capable of returning the valve to a normally open or normally closed position following loss of power.
q. All spring return actuators must be designed for either normally open or normally closed fail-safe operation with a continuously engaged mechanical return spring. This spring must return the actuator to a fail-safe position within 20-25 seconds of power loss.
r. All 5Nm torque, spring return actuators must be able to spring return from -40°F to 150°F.
s. Proportional and floating control actuators shall provide a 2-10 Vdc feedback signal. The signal shall represent the actual flow (gpm) to the associated coil, providing a gpm input to the DDC controller.
t. Actuators shall be available with SPST or SPDT switch for position verification feedback as an available option.

6. Control valves 2 ½ to 6 inches: Valves shall be available with wafer-flanges for use with either ANSI/ASME 125/150 or ANSI/ASME 250/300 pipe flanges in sizes from 2 ½ up to 6 inches (DN65 to DN150). Each wafer flange shall be useable with either of two successive pipe sizes.

a. Minimum Requirements:
1) Flow control valve shall be individually flow tested at the factory and verified to deviate no more than +/-5% though the minimum to maximum pressure range.
2) Flow control valve shall have minimum 50:1 rangeability with an equal percentage flow characteristic provided by a multi-turn, non-rising stem, characterized plug.
3) Valve trim shall be stainless steel.
4) Maximum operating differential pressure rating shall be no less than 58 psid. Close-off pressure shall be 100 psid minimum, at no more than 0.2% leakage.
5) Valve bodies shall have static pressure rating of 580psig (4000kPa) at 248°F (120 C).
6) Valve stem seals shall be EPDM O-rings and be field-replaceable without removing the valve body from the piping.
7) Multiple gpm flow ratings shall be field-selectable in each valve size, with 50 unique settings.
8) Actuated valves shall be capable of closing off against their maximum operating differential pressure. Seat leakage when closed shall be ANSI/ASME Class IV, minimum.
9) Actuators shall be direct coupled six turn rotary type requiring neither crank-arm nor linkage and direct mount to the valve actuator bracket.
10) Actuators shall be capable of operating on 24Vac Class II power, in both electronic fail-safe and stay-in-place configurations. Actuator fail-safe action in the event of power failure shall be field-selectable normally open or normally closed.
11) Actuators shall provide screw terminal wiring connections with adapters for flexible conduit where mechanical protection is required by local codes.

12) Actuators shall have a programming DIP switch accessible under the cover to change between proportional, floating, or pulse width modulation (PWM) control or two-position control through wiring options.
13) Proportional actuators shall have field-adjustable signal zero and span adjustments.
14) Actuation shall be available with electronic fail-safe operation capable of returning the valve to a normally open or normally closed position following loss of power.
15) Proportional and floating control actuators shall provide a 2-10 Vdc feedback signal. The signal shall represent the actual flow (gpm) to the associated coil, providing a gpm input to the DDC controller.

7. General Requirements:

2.12 Valve Schedule: Valve take-off and selection shall be performed and a schedule created by the valve manufacture. Schedule including a separate line for each valve and a column for each of the valve attributes: Valve Identification Tag, Location, Valve Type, Valve Size, Pipe Size, Configuration, Flow Capacity, Minimum Design Pressure Drop, Maximum Pressure Drop, Fail Position, Close-off Pressure, Actuator Identification Tag, and Actuator Type. The valve manufacture's authorized distributor shall either, directly prepare the valve with actuator combination submittal or review and approve the submittal prepared by the contractor prior to submission for Architect/Engineer's approval.

2.13 Valves shall not be installed with stems below the horizontal plane to prevent actuator damage due to stem seal leakage, or accumulation of particulate in the stem packing.

2.14 Valves shall be capable for use only in cold, warm, and hot water system applications with diethylene glycol, ethylene glycol, or propylene glycol solutions up to 50% concentration.

2.15 A water filtration and treatment system shall be installed and operated according to the requirements of Division 23 25 13, Water Treatment for Closed-Loop Hydronic Systems. These requirements shall meet or exceed European Norm VDI 2035. The presence of excess rust in the system will void the manufacturer's warranty.

2.16 Run time shall be constant and independent of: load, temperature, and supply voltage (within specifications).

2.17 Accessories Identification tags shall be available for all valves; tags shall be indelibly marked with gpm, model number, and tag location.

A. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:

a. Two Position: Line size.
b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

B. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer.
2. Disc Type: Nickel-plated ductile iron.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

C. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

D. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Thermostatic Operator: Liquid-filled integral sensor with integral adjustable dial.

2.18 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units.

B. Verify that ductwork and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install control units and operators. Implement all features as required to achieve sequence of operation.

B. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

C. Provide stainless steel plate type sensors in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

D. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

G. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

H. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. ALL control and interlock wiring shall comply with the national and local electrical codes and Division 26 of these specifications and shall be the responsibility of the controls contractor. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.

B. All Class 1 (line voltage) wiring shall be UL listed and run in approved raceway in accordance with NEC and Division 26 requirements.

C. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

2. All cables shall be UL listed for application, i.e. cables used in ceiling plenums shall be UL listed specifically for that purpose. Where plenum cables are used without raceways, they shall be supported from or anchored to structural members.

3. Except in ceiling plenums, all exposed control wiring shall be run in conduits.

D. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

E. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result.

F. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

G. Contractor shall provide step down transformers, as needed.

H. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

I. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.

J. Size of conduit and gauge and type of wire shall be the design responsibility of this Contractor, in keeping with the manufacturer's recommendation and NEC.

1. Conduits are required for control wiring runs located in walls.

K. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.

L. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.

M. Adhere to Division 26 requirements for installation of raceway.

N. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

O. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

D. All control wiring to be labeled within 2 inches of each termination with a tag that complies with the naming convention specified in 2.2/F/2 of this Section.

E. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

F. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

H. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

I. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

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

   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.

C. Control System Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check system as follows:

    a. Verify that controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.

e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

6. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

7. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
8. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
9. Provide diagnostic and test instruments for calibration and adjustment of system.
10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three 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 HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training."

3.7 SEQUENCE OF OPERATIONS:

A. Geothermal-Source Heat Pumps
1. Occupied Mode
a. The BAS shall index the water source heat pump into the occupied mode by pressing override on space sensor or from the operator workstation with time schedule or manual command. Once in the occupied mode the fan will run continuously and the compressor will cycle to maintain occupied space heating and cooling set points.
2. Unoccupied Mode
a. Once in the unoccupied mode the fan and the compressor will cycle from the space sensor to maintain unoccupied space heating and cooling set points.

b. Monitored or controlled points (typical for each of heat pump):

Point Name	Type
Space Temperature	AI
Space Bias	AI
Discharge Air Temperature	AI
Leaving Water Temperature	AI
Unit General Alarm	BI
Fan Command	BO
Heating Command	BO
Cooling Command	BO
General Alarm Reset	BO
Tenent Override Reset	BO

B. Geothermal Loop Pumps (P1 & P2):

1. Pump Control:

1. Lead pump will ramp up and shall continue to ramp up to maintain loop differential pressure between the supply and return as measured 2/3rds out in system piping. If the lead pump is not able to maintain loop differential pressure set point, the lag pump shall enable and ramp up to maintain loop differential pressure. An alarm will be recorded at operator workstation. The BAS will monitor the status of each pump. The status from each pump will be used to equalized runtime. Each pump shall run for an adjustable length of time, before the other pump takes over and shall run for equal length of time.

2. Sequencing pumps will be based on the flow requirements of heat pumps in operation. Each heat pump will have a water valve that will be closed when its compressor is not in operation. When the compressor is required to operate, its associated water valve shall open before the compressor operates.

3. Monitored or controlled points:

Point Name	Type
Pump P-1 Command	BO
Pump P-1 Signal	AO
Pump P-1 Status	BI

Pump P-1 VFD Alarm	BI
Pump P-1 Runtime	AI
Pump P-2 Command	BO
Pump P-2 Signal	AO
Pump P-2 Status	BI
Pump P-2 VFD Alarm	BI
Pump P-2 Runtime	AI
Loop Differential Pressure	AI

2. Geothermal Temperature Loop Control
   a. Occupied Mode/Unoccupied:
      1) The loop water temperature shall be maintained to be between 40-90deg.F. for system operation.

   b. Alarms
      1) The loop controller shall provide an alarm and emergency shutdown signal as follows:
         a) Alarm if loop temperature rises to 90deg.F., shutdown at 100deg.F. (high limit).
         b) Alarm if loop temperature falls to 30deg.F., shutdown at 20deg.F. (low limit)
         c) Alarm and shutdown for lack of loop water flow.

C. Energy Recovery Ventilator(s) – ERV-1 & ERV-2
   1. A field supplied and installed DDC controller will be wired to the ERV to enable/disable the ERV's. During the occupied mode the supply and exhaust fan shall run continuously. The Manufacturer will provide preprogrammed controls for defrost mode, etc.
   2. A freeze stat and discharge air sensor will provide for an alarm and duct temperature indication.
   3. A current sensor shall be installed to report run status of the unit.
   4. When either ERV units are enabled the DDC controller shall open both the Outside Air and Exhaust dampers at the building envelope. If both ERV units are not running the DDC controller will close both the Outside and Exhaust Air Dampers.

D. Split System air Conditioners (CRAC-1):
   1. The cooling shall be controlled thru the factory provided 7 day programmable thermostat. The fan shall run only when cooling/heating is enabled to maintain space temperature (adj.) and humidity (adj.). The thermostat shall cycle cooling to maintain space temperature of 75degF (adjustable).
   2. BACnet Integration, the CRAC unit is to be furnished with BACnet IP card for integration by the Temperature Controls Contractor.

E. Exhaust Hood Fans (F-1,2)
   1. Hood Exhaust Fans will be manually controlled by a wall switch.

F. Paddle Fans (PF-1,2)
   1. Paddle Fans will be manually controlled by a wall speed controller.

G. Electric Wall Heaters
   1. Electric Wall Heaters will be controlled off an integral thermostat furnished and installed by the manufacturer.

H. Electric Duct Heaters
   1. EDH-1: A field installed DDC controller shall stage the electric duct heater to maintain a discharge air temperature of 45°F adj.
   2. EDH-2,3,4: Electric Duct heaters will be controlled off of relay boards furnished by the VRF manufacturer.

I. VRF Systems (DS 2-11, VRF 1,2 BS-1,2)
   1. The VRF system will be supplied with wall controllers, thermostats and (1) BACnet/IP gateway. The DDC contractor will install the wall controllers and thermostats as well as wire all units back to the BACnet/IP gateway. The DDC contractor will require assistance from the manufacturers' rep during start up for a list of BACnet objects to integrate to.

END OF SECTION 230900

SECTION 233533 – Exhaust Hood

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. Exhaust hoods

1.3 ACTION SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's data and installation instructions for each type of fume hood. Provide data indicating compliance with ASHRAE Standard 110.1995.

B. Samples: Samples if called for will be reviewed for color, texture, and pattern only. Submit the following:

   a. Hood interior lining, 6 by 6 inches.

   b. Hood enclosure, 6 by 6 inches, of color selected.

   c. Operation sign(s).

   d. Shop Drawings: Submit shop drawings for fume hoods showing plans, elevations, ends, cross-sections, service run spaces, location and type of service fittings:

   1) Coordinate shop drawings with other work involved.

   2) Provide roughing-in drawings for mechanical and electrical services when required.

   3) Provide face opening, air volume, and static pressure drop data.

C. Shop Drawings: For listed exhaust hoods.

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Detail fabrication and assembly of hangers and seismic restraints.

D. Non-Specified Manufacturer's Samples:

1. A sample from each non-specified manufacturer will be required and reviewed per specification. This sample shall be delivered, at no cost to the architect or owner to a destination set forth by the architect or owner. The sample must then be tested per section 1.4.C by an independent test agency hired by the submitting company and approved by the owner/architect. A passing test and owner/architect approval of the prototype must be written and approved seven (7) days before quotation deadline as a condition of acceptance for any quotation participant.

1.4 STANDARD FUME HOOD PERFORMANCE REQUIREMENTS

A. Fume hoods shall be of complete airfoil design to insure maximum operating efficiency. Foil sections at the front of the hood shall minimize eddying of air currents at the hood face and the rear baffle system shall minimize turbulence in the upper portion of the hood interior.

B. Standard Fume Hood Types
1. Open Bypass: The hoods shall be of the bypass type. The fume hood design shall allow for automatic air bypass above the sash opening. The bypass shall limit the maximum air velocity through the face of the hood and provide for a constant volume of air through the hood regardless of sash position. The bypass shall control the increase in face velocity as the sash is lowered to limit the maximum velocity to not more than three and one-half, times the velocity with the sash full open.

C. Containment
1. Purpose: The purpose of this specification is to prequalify the performance of the bidder's laboratory fume hood before award of contract. At his option, the owner or his representative may require the same tests to be performed and the same performance be achieved before acceptance of the hood after award of contract. The owner or his representative shall witness the tests. Failure to meet the performance specified shall be cause for rejection of the bidder.
2. Test Method: The hood shall be tested per the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 110-1995.
3. Instrumentation, Equipment and Test Personnel: Qualified personnel to perform the tests shall be supplied by the bidder. Instrumentation and equipment required shall be supplied by the bidder at his expense. Required instrumentation shall include but not be limited to the following items:
    a. Thermal anemometer capable of measuring air velocities from 10 to 600 ft./minute
    b. Three dozen one-half minute smoke candles
    c. Four ounces of Titanium Tetrachloride
    d. Supply of cotton throat swabs
    e. ITI Leakmeter 120 calibrated to indicate concentration of sulfur hexafluoride or equivalent
    f. Flowmeter – 150 ml/minute capacity
    g. Flowmeter – 15 L/minute capacity
    h. Four gas sampling bags – 8 liter capacity
    i. Two vacuum pumps – 1 CFM capacity
    j. Two flow regulating valves
    k. Two size 3 tanks of sulfur hexafluoride with a two-stage regulator or other tracer gas suitable for detector to be used
    l. Three-way gas valve

m. Mannequin, 5’7” in height, or reasonable human proportions with arms hanging at its side
n. ASHRAE 110-1995 tracer gas ejector

4. ASHRAE Standard 110-1995 Test: Hood shall be tested with a face velocity of 100 FPM full open vertically and at 100 FPM right, left and center 100% open horizontally. If horizontal openings are present, additional sash configurations and face velocities may be specified. The hood shall have a performance rating of 4.0 AM 0.01 or better wherein:
   a. 4.0 = tracer gas release in liters/minute
   b. AM = as manufactured
   c. 0.01 = level of control of tracer gas in parts per million (ppm).

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in listed grease ducts and field-fabricated grease ducts.

B. The laboratory fume hood manufacturer shall provide fume hood work tops and casework all manufactured or shipped from the same geographic location to assure proper staging, shipment and single source responsibility.

1.7 RELATED PUBLICATIONS

A. ASHRAE Standard 110.1995 - Method of Testing Performance of Laboratory Fume Hoods

B. NSF STD#49 – Photometric Method of Testing

C. NIH03-112C - National Institute of Health Specification

D. UL – Underwriters Laboratories

E. ASTM D552 – Bending Test

F. NFPA-45 – National Fire Protection Association

1.8 BASIS OF WORK

A. It is the intent of this specification to use Kewaunee Scientific Corporation, Statesville, North Carolina, as the standard of construction for laboratory fume hoods. The construction standards of the Kewaunee Supreme Air product line shall provide the basis for quality and functional installation.

B. Supply all equipment in accordance with this specification. The offering of a product differing in materials and construction from this specification requires written approval. This approval must be obtained seven (7) days before the proposal deadline. Procedures for obtaining approval for an alternate manufacturer are defined in section 2.00 C. in this specification.

C. The owner/architect reserves the right to reject qualified or alternate proposals and to award based on product value where such action assures the owner greater integrity of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The basis of this specification is the Supreme Air fume hood as manufactured by Kewaunee Scientific Corporation
   1. An equal product must be approved by an engineer.

B. All laboratory equipment covered by the specification shall be the product of one manufacturer and be fabricated at one geographic location to assure shipping continuity and single-source responsibility. All quotations from a manufacturer other than Kewaunee Scientific shall contain a review of the following capabilities:
   1. List of shop facilities
   2. List of engineering and manufacturing personnel
   3. Proof of financial ability to fulfill the contract
   4. List of a minimum of ten installations over the last five years of comparable scope
   5. Proof of project management and installation capabilities

C. The selected manufacturer must warrant for a period of one-year starting (date of acceptance or occupancy, whichever comes first) that all products sold under the contract referenced above shall be free from defects in material and workmanship. Purchaser shall notify the manufacturer’s representative immediately of any defective product. The manufacturer shall have a reasonable opportunity to inspect the goods. The purchaser shall return no product until receipt by purchaser of written shipping instructions from the manufacturer.

2.2 MATERIALS AND CONSTRUCTION

A. Fume Hood Superstructure Frame: A free-standing rigid frame structure of steel angle shall be provided to support exterior panels and interior liner and baffle panels. To allow for maintenance and replacements, the interior liner panels shall be removable without disassembly of the frame structure and outer steel panels. Likewise, the exterior steel panels shall be removable without disassembly of the frame structure and inner liner panels. Fume hoods that require disassembly of the superstructure for liner replacement are not acceptable.

B. Fume Hood Interior Walls: Double wall ends, not more than 4” wide, shall be provided to maximize interior working area. The area between the double wall ends shall be closed to house the remote control valves. The front vertical facia section shall have a full 135 degree 1” radius at the front leading edge to provide a streamlined section and insure smooth even flow of air into the hood. The vertical facias shall contain the required service controls, electrical switches

and receptacles. The hood interior end panels and sash track shall be flush with the facia to prevent eddy currents and back flow of air.

C. Fume Hood Airfoil: A streamlined airfoil shall be integral at the bottom of the hood opening on bench and distillation hoods. This foil shall provide a nominal 1” open space between the foil and the top front edge of the work surface to direct an air stream across the work surface to prevent back flow of air. The airfoil shall extend back under the sash, so that the sash does not close the 1” opening. The foil shall be removable to allow large equipment into the hood. The foil shall be of 12-gauge steel to resist denting and flexing. Walk-in hoods shall have a stop located at the bottom of the sash track that will ensure a nominal 1” opening between the bottom of the sash and the floor.

D. Access Opening: The interior end liner panels shall be furnished with an opening that provides access to the service piping and valves to facilitate installation and maintenance. The openings shall be covered with a removable panel with rounded corners. Panels that require tools to remove are not acceptable. The panel shall provide an overlapping seal on all edges.

E. Fume Hood Finish: After the component parts have been completely welded together and before finishing, they shall be given a pre-paint treatment to provide excellent adhesion of the finish system to the steel and to aid in the prevention of corrosion. Physical and chemical cleaning of the steel shall be accomplished by washing with an alkaline cleaner, followed by a spray treatment with a complex metallic phosphate solution to provide a uniform fine grained crystalline phosphate surface that shall provide both an excellent bond for the finish and enhance the protection provided by the finish against humidity and corrosive chemicals. After the phosphate treatment, the steel shall be dried and all steel surfaces shall be coated with a chemical and corrosion-resistant, environmentally friendly, electrostatically applied powder coat finish. All components shall be individually painted, insuring that no area be vulnerable to corrosion due to lack of paint coverage. The coating shall then be cured by baking at elevated temperatures to provide maximum properties of corrosion and wear resistance.

F. Fume Hood Dimensions: Double wall end panel thickness shall not exceed 4”. Interior clear working height shall be not less than 41-3/4” at any location in the interior of the hood on bench hoods and 76” on walk-in and distillation hoods. Interior depth from the back of the sash to the front of the rear baffle shall not be less than 25-1/4”. The sash opening shall be not less than 28” in height above the worksurface on bench hoods.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Preparation: Prior to beginning installation of fume hood, check and verify that no irregularities exist that would affect quality of execution of work specified.

B. Coordination: Coordinate the work of the Section with the schedule and other requirements of other work being performed in the area at the same time both with regard to mechanical and electrical connections to and in the fume hoods and the general construction work.

C. Performance: Install fume hoods, plumb, level, rigid, securely anchored to building and adjacent furniture in proper location, in accordance with manufacturer's instructions and the approved shop drawings. Provide filler panels between top of hood and ceiling. Securely attach access panels but provide for easy removal and secure reattachment. Do not install any damaged units.

D. Adjust and Clean:
   1. After installations are complete, adjust all moving parts for smooth operation.
   2. Remove all packing materials and debris resulting from this work, and turn over the fume hoods to the Owner clean and polished both inside and out.
   3. Repair or remove and replace defective work, as directed by owner and/or his representative upon completion of installation.

E. Protection:
   1. Provide reasonable protective measures to prevent casework and equipment from being exposed to other construction activity.
   2. Advise owner and/or his representative of procedures and precautions for protection of material, installed laboratory casework and fixtures from damage by work of other trades.

END OF SECTION 233533

SECTION 234133 - HIGH-EFFICIENCY PARTICULATE AIR FILTRATION

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. HEPA rigid-cell box filters.
2. HEPA V-bank cell filters.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for HEPA filters.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate.

B. HEPA: High-efficiency particulate air.

C. PAO: Poly-alpha-olefin.

D. PSL: Polystyrene latex.

E. ULPA: Ultralow penetration air.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, 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.

B. Product Test Reports: For each filter, for tests performed by a qualified testing agency.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.7 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. Provide two complete sets of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean, dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.

2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.0.

B. ASHRAE 62.1 Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

C. Comply with NFPA 90A and NFPA 90B.

D. Comply with UL 900.

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

2.2 HEPA RIGID-CELL BOX FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow and with holding frames.

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. AAF International.
b. AirGuard; Clarcor Air Filtration Products, Inc.
c. Air-Nu.
d. Camfil Farr.
e. Flanders Corporation.
f. Glasfloss Industries.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

D. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None.
2. Media to Filter Frame Seal Material: Polyurethane.
3. Faceguard Material: Match corresponding duct material.
4. Faceguard Location: Upstream.

E. Filter-Media Frames:

1. Material: Aluminum.
2. Filter Frame to Mounting Frame Seal Material: Neoprene.
3. Filter Frame to Mounting Frame Seal Location: Upstream.
4. Style: Box.

2.3 HEPA V-BANK CELL FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media at an angle to airflow and with holding frames.

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. AAF International.
b. Camfil Farr.
c. Flanders Corporation.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

D. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None.
2. Media to Filter Frame Seal Material: Polyurethane.

E. Filter-Media Frames:

1. Material: Aluminum.
2. Filter Frame to Mounting Frame Seal Material: Neoprene.
3. Filter Frame to Mounting Frame Seal Location: Upstream.

4. Style: Box.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF FILTERS

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.

D. Coordinate filter installations with duct and air-handling unit installations.

3.3 INSTALLATION OF HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

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

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

D. Perform tests and inspections.

E. Tests and Inspections:

1. HEPA and ULPA Filters: Pressurize housing to a minimum of 6.0-inch wg, and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME AG-1.

F. Air filter will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

3.7 PROTECTION

A. Protect installed products and accessories from damage during construction.

END OF SECTION 234133

SECTION 238119 - VARIABLE REFRIGERANT FLOW (VRF) SYSTEM EQUIPMENT

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. DS Concealed Unit
2. VRF Heat Pump
3. Branch Selector Box
4. Indoor, Energy Recovery Ventilator

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

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 diagrams for power, signal, and control wiring.

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 VRF Ducted Concealed/VRF Ceiling Suspended 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. Access panels.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF ducted concealed unit, VRF ceiling suspended unit, outdoor condensing units, and branch selector boxes include emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," 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. Ducted Concealed Units: Furnish one spare filter 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."

1.8 COORDINATION

A. Coordinate layout and installation of VRF ducted concealed units/ceiling suspended unit 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: 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.

2. Warranty Period (Parts Only): Ten years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED SPLIT UNIT

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

a. Daikin
b. Mitsubishi Electric
c. LG
d. Samsung

B. Ducted Split Concealed Unit Arrangement: Horizontal Discharge.

C. Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

D. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

E. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Connection: Steel flange connection.
2. Return-Air Connection: Steel flange connection.
3. Cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV 13) according to ASHRAE 52.2 and all addendums.

G. Indoor Refrigerant Coils: Copper tube with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

H. Direct-Driven Fans: Direct-drive DC (ECM), statically and dynamically balanced impeller; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Control devices and operational sequence are specified in Section 230548 "Vibration Controls for HVAC Piping and Equipment."

J. Basic Unit Controls:

1. Control voltage transformer.
2. The unit shall have controls provided by manufacturer to perform input functions necessary to operate the system.
3. Provide an “in-room” sensor for rooms not being controlled by unit’s main thermostat.
4. Wall-mounting thermostat with the following features.

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Automatic changeover.
    d. Exposed set point.
    e. Degree F indication.
    f. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    g. Output data includes room temperature and humidity, supply-air temperature, operating mode, and status.
5. The unit shall be compatible with an advanced web-based multi-zone controller. The web-based controller must have the capabilities for owner or building manager to monitor system.

6. Refrigerant-Coil Operation:

    a. Occupied Periods: Start compressor to maintain room temperature.
    b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.

7. Supplemental Heating-Coil Operation:

    a. Occupied Periods: Energize electric-resistance coil to provide heating if outdoor temperature falls below 10 deg F.
    b. Unoccupied Periods: Energize electric-resistance coil if room temperature falls below setback temperature.

K. Electrical Connection: Factory wire motors and controls for a single electrical connection.

L. Capacities and Characteristics: (AS SCHEDULED)

2.3 HEAT PUMP

A. Manufacturers: The condensing unit is designed specifically for use with the ceiling suspended units by same manufacturer.

   a. Daikin
   b. Mitsubishi Electric
   c. LG
   d. Samsung
   e. Aston

B. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

C. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

   1. Shall be completely weatherproof and corrosion resistant.
   2. Shall be constructed from rust-proof mild steel panels.

D. Condensing Coil: Copper tubes with corrosion-resistant coating, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

E. Corrosion-Resistant Coating:

   1. Fins shall be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.

F. Direct-Driven Fans: Direct-drive DC, propeller type fans; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

   1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

G. Electrical Connection: Factory wire motors and controls.

H. Capacities and Characteristics: (AS SCHEDULED)

2.4 BRANCH SELECTOR BOX

A. Manufacturers: The branch selector box unit is designed specifically for use with the ducted concealed units by same manufacturer

   a. Daikin
   b. Mitsubishi Electric
   c. LG
   d. Samsung

B. Branch Selector Arrangement: Suspended from ceiling/roof structure.

C. Chassis: Galvanized steel where exposed to moisture**,** with baked-enamel finish and removable access panel.

D. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

E. Basic Unit Controls:

1. Control voltage transformer.

F. Electrical Connection: Factory wire motors and controls for a single electrical connection.

G. Capacities and Characteristics: (AS SCHEDULED)

2.5 INDOOR, ENERGY RECOVERY VENTILATOR

A. Description: Factory-assembled and -tested complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Damper Assemblies:

1. Outdoor Air Intake and Exhaust Air Discharge:

a. Low-leakage damper with spring return electric actuator to fail closed on loss of power.
b. Damper controlled by unit to open when unit is operating and close when unit off.

D. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.

1. Fan(s):

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
c. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

E. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.

1. Access: To accommodate filter replacement without the need for tools.
2. Efficiency: ASHRAE 52.2, MERV 7.
3. Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

F. Energy Recovery Heat Exchanger:

1. Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.
2. Fixed element with no moving parts.
3. AHRI 1060 certified and bearing the AHRI labe1.

G. Unit Controls:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit entering outdoor air temperature.
    b. Unit leaving supply air temperature.
    c. Unit entering exhaust air temperature.
    d. Unit leaving exhaust air temperature.

4. Field-Customizable I/O Capability:

    a. Analog Inputs: Three for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control, local auto operation mode, manual operation mode, filter service notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

I. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units 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 ducted concealed/ceiling suspended units level and plumb.

B. Install ducted concealed/ceiling suspended units to comply with NFPA 90A.

C. Suspend ducted concealed/ceiling suspended units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration Controls for HVAC Piping and Equipment."

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

E. Install new filters in each ducted concealed unit within two weeks after Substantial Completion.

F. Provide control/transmission wiring from unit to remote controller.

3.3 CONCRETE EQUIPMENT BASES

A. Minimum Compressive Strength of 4000 psi at 28 days. Nominal maximum aggregate size of 1-1/2-inch Plain-Steel Welded-Wire Reinforcement.

B. Brush finish with chamfer edges. Nominal 4 inches high pad. Coordinate pad size with size of equipment. Provide dowels and inserts required for equipment mounting prior to pouring concrete.

3.4 CONNECTIONS

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

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to ducted concealed/ceiling suspended unit factory refrigerant piping package. Install piping package if shipped loose.
3. Connect condensate drain to condensate Schedule 40 PVC piping.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

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

3.5 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. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. 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.

3.6 ADJUSTING

A. Adjust initial temperature 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.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train owner's maintenance personnel to adjust, operate, and maintain all VRF system equipment.

END OF SECTION 238219

SECTION 23 81 47 - GEOTHERMAL LOOP FIELD PIPING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Excavation and backfill of every description and of whatever substances encountered, to the depths required or indicated on the drawings, in accordance with Division 31 – Earthwork Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Underground polyethylene heat exchangers. The extent of ground heat exchanger work is indicated on the drawings and schedules, and by the requirements of this section. The buried heat exchangers consist of polyethylene heat-fusion joined piping horizontal piping connecting the previously capped loops to the valved manifold assembly. The loops include the thermally enhanced grout and flow fill materials.
2. HDPE pipe and fittings
3. Grouting materials
4. Casing

1.3 QUALITY ASSURANCE

A. Provide 50-year manufacturer’s standard material warranty for HDPE pipe and fittings. Provide installer’s 1-year warranty on the piping installation.

B. Guidelines of the National Ground Water Association shall be followed for the backfilling vertical bore holes. Thermally enhanced bentonite shall be evenly distributed throughout the entire bore to provide maximum heat transfer without voids.

C. Flow Fill material to be used to “top-off” vertical bores to enhance the near surface stability of the formation.

D. Thermal Fusion Technician shall be trained in methods of forming thermally fused joints. Must have completed a polyethylene heat fusion school and have successfully completed the course requirements. Must be able to produce proof of training upon request.

1.4 SUBMITTALS

A. For Approval - Provide manufacturer's catalog sheets, specifications, and installation instructions for each item specified including but not limited to:

1. HDPE pipe and fittings
2. Thermally enhanced grout material and mix contents

B. HDPE Piping 50-Year Warranty Certificate

C. Record and As-Built Drawings

1. Maintain at the job site a record set of Loop Field drawings on which any changes in location or routing of piping or equipment shall be recorded.
2. Accurately record, on site plan, dimensioned “as built” drawing showing depth and location of horizontal piping and location of each bore hole, measured from two permanent fixtures such as corner of building.
3. At the end of construction, the Contractor shall provide the Owner with a complete set of as-built drawings, including all up-dated record drawings. Prepare the as-built drawings using the most recent version of AutoCAD or other suitable CAD software. Provide the Engineer with .pdf file of the as-built drawings.

E. Loop pressure test plan & results. Procedures shall be approved prior to commencement of pressure test activities. Provide a 2 working day notification to the Engineer prior to conducting pressure tests.

1. If any pressure tests fail, what action was taken to correct the problem

1.5 REFERENCE STANDARDS

A. ASHRAE 1995 Commercial/Institutional Ground Source Heat Pump Engineering Manual (ISBN 1-883413-21-4)

B. ASHRAE 1997 Ground Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings. (S.P. Kavanaugh and K. Rafferty) (ISBN 1-883413-52-4) Grout Thermal Conductivity and Vertical Loop Design by C. P. Remund

C. International Ground Source Heat Pump Association (IGSHPA) Standard for Installation of Ground Source Heat Pump Systems.

D. National Ground Water Association's Guidelines for the Construction of Vertical Boreholes for Closed Loop Heat Pump Systems.

E. Plastics Pipe Institute, Inc (PPI), TR-4/2010 HDB/HDS/SDB/PDB/MRS for Thermoplastic Piping Materials or Pipe; http://plasticpipe.org/pdf/tr-4_hdb_hds_sdb_pdb_mrs_listed.pdf

F. ASTM A53/A53M-10 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

G. ASTM C1107/C1107M-08 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

H. ASTM D1785-15 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

I. ASTM D2837-13 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

J. ASTM D3350-14 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

K. ASTM D3261-16 Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

L. ASTM D1693-15 Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

M. ASTM F2164-13 Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

N. ASTM F1055-16 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing

PART 2 - PRODUCTS

2.1 POLYETHYLENE (HDPE) PIPE AND FITTINGS

A. Pipe:

1. The material shall maintain a 1600 psi Hydrostatic Design Basis at 73.4 degrees Fahrenheit per ASTM D2837, and shall be listed in PPI TR4 as a PE4710 piping formulation. The material shall be a high density, polyethylene extrusion compound having a cell classification of PE445574C with a UV stabilizer of C as specified in ASTM D3350. This material shall exhibit zero failures (FO) when tested for 500 hours under ASTM F1473 as required in ASTM D3350.

B. Fittings:
   1. Fittings shall be compatible with the pipe material or from the same material as the pipes.
   2. Socket fusion fittings shall conform to ASTM D2513 & ASTM D2683.
   3. Butt fusion fittings shall conform to ASTM D3261.
   4. Saddle fusion fittings shall conform to ASTM D3261 or ASTM D2513 & ASTM D2683.
   5. Electro-fusion fittings shall conform to ASTM F1055.

C. Joints:

   1. Thermally fused per manufacturer's requirements. Under no circumstances shall mechanically coupled pipe joints be installed underground.
   2. No joints in vertical tubing; maximum of two joints at factory-assembled single-piece U-bend. Under no circumstances will field fabricated U-bends be permitted for the vertical loop piping.

D. Miscellaneous:

   1. Markings: Pipe shall be marked with manufacturer's name and product name, nominal size, ASTM dimensional standard, PPI material classification, cell classification, sequential footage, and manufacturer's date code. Print line shall repeat every two feet with sequential footage from the U-bend in two (2) foot increments.

E. Dimensions:

   1. Pipe with a nominal dimension of 2" or smaller shall be manufactured in accord with ASTM D3035 with a dimension ratio of 11.
   2. Pipe with a nominal dimension of 3", 4" & 6" shall be manufactured in accord with ASTM D3035 with a dimension ratio of 15.5.

F. Pipe Joining Methods:

   1. The only acceptable method for joining buried pipe systems is by a heat fusion process.
   2. Polyethylene pipe shall be butt, socket, saddle or electro-fused in accord with pipe manufacturer's procedures.
   3. Tubing shall be free from defects in material and workmanship.

2.2 GROUTING MATERIALS

A. Thermally Enhanced Bentonite Grout

1. Grouting material shall be GeoPro's Thermal Grout product or equal.
2. Material is to be placed in borehole from bottom to a depth 10-20 feet below grade.
3. The thermal conductivity of the grouting compound must be 1.2 Btu/hr-ft-ºF or greater.
4. The grout mixture shall have a maximum permeability rate of 1.0 x 10-7 cm/s as determined by ASTM D-5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with increasing tailwater level", per IGSHPA Standard 2B.1.2.2, with a 5 psi confinement pressure (to simulate an approximate sample depth of 5 ft.). The reported permeability shall be verified by an independent, lab certified by AMRL (American Association of State Highway & Transportation Officials, Materials Reference Laboratory) and validated by the US Army Corps of Engineers to perform ASTM D-5084 at the time of verification as per IGSHPA Standard 2B.1.2.3. A copy of the report shall be supplied upon request from the engineer. Credentials of the independent laboratory shall also be supplied upon request from the engineer.
5. The thermal conductivity of the grouting compound must be 1.20 Btu/hr-ft-°F or greater as determined when tested in accordance to ASTM D-5334, "Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure" per International Ground Source Heat Pump Association (IGSHPA) Standard 2B.1.2.1. Upon request, supplier must be able to produce independent, third party verification of the grouting material's ability to achieve the specified thermal conductivity. The independent company verifying the thermal conductivity of the grouting material shall have a minimum of 5 years of experience in measuring thermal conductivity using the methods outlined in ASTM D-5334. Date of independent verification testing and reporting shall be no more than three (3) years prior to the date of request from the engineer.

B. Cementitious Flow Fill

1. Material shall be a mixture of Portland Cement (6.1% by wgt), Sand (85.6% by wgt), Water (8.3% by wgt) and 1 capsule of Darafill.
2. Mixture shall be used to fill space in top of bore created by any settling of the Thermally Enhanced Grout up to a depth 6 feet below grade. The depth of Flow Fill shall not exceed 20 feet.

2.3 CASING

A. All permanently installed casing shall be 17 lbs/ft steel casing.

PART 3 - EXECUTION

3.1 GENERAL

A. Protection of Existing Utility Structures. Protect the existing utilities shown on the drawings or not in the locations of which are known or unknown prior to excavation, from damage during excavation and backfilling of trenches and, if damaged, repair all damage at no expense to the Owner. Notify construction manager of any existing line or utility structure that is not shown on the drawings.

B. Make repairs under the supervision of the utility concerned.

C. Ground field layout shall be capable of being purged of air and debris, and connected in a minimum number of trenches and/or pits.

D. Fill U-bend loops with water and insert the U-bend into the bore to the depth stated in the design documents.

E. Examine areas and conditions under which ground heat exchanger systems are to be installed. Verify that the loop layout is appropriate for site conditions. After approval from Engineer, correct site problems before proceeding.

F. Thermally enhanced bentonite grout shall be used to create a thermal bridge and water seal along the vertical axis of the bore hole.

G. Cut polyethylene pipe with approved knife blade cutting tool only. Saw cut is unacceptable.

H. Control the “run-off” of water and cuttings through the use of excavation, hay bales and/or silt fence to form a settling area allowing the cuttings to settle out and the water run-off is clear. Legally remove or dispose of cuttings.

3.2 PREPARATION – EXCAVATION

A. General: Perform all excavation of every description and of whatever substances encountered, to the depths required or indicated on the drawings, in accordance with Spec Section 31 0000 - Earthwork.

1. Legally dispose of all excavated material.
2. Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove any water accumulating therein by pumping or by other acceptable method.
3. Unless otherwise specified, all excavation shall be by open cut. Fill any excess excavation below the levels indicated for structures or pipe with sand, gravel or concrete, as directed by the Engineer.

B. Trench Excavation: Excavate true to line and provide a clear space on either side of the pipe to facilitate bedding.

1. Heat exchanger horizontal piping shall be provided with a minimum cover of five (5) feet to final grade.
2. Unsuitable Material: Where the bottom of the trench is found to be unstable or to include ashes, cinders, all types of refuse, vegetable or other organic material, or

large pieces of fragments of inorganic material, which in the judgment of the Engineer should be removed, excavate and remove such unsuitable material to a minimum depth of 12 inches below the pipe.

3. Backfill the trench with select bedding material and compact to provide uniform and continuous bearing for the pipe. Dispose of the unsuitable material.
4. Shoring Requirements: Perform all shoring and sheeting that is required to protect the excavation and to safeguard employees in accordance with OSHA or local codes having jurisdiction. Widen excavation to provide for space occupied by shoring and sheeting.
5. Shoring shall meet the requirements of all applicable codes and regulations.

C. Cold Weather Protection. Protect excavation bottoms against freezing when atmospheric temperature is less than 35ºF.

D. Dewatering: Do not allow water to accumulate in excavations. Prevent surface water and subsurface or groundwater from flowing into excavations.

E. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations adjacent buildings and construction.

3.3 INSTALLATION

A. Excavation and vertical drilling work shall be performed by qualified Contractors.

B. Pipe shall be installed in accordance with recommendations of ASHRAE and IGSHPA. Pipe joints shall be heat fusion type and shall be made as recommended by the pipe manufacturer.

C. Open ends of all pipe shall be sealed at all times to prevent entry of contaminants until final connections are made.

D. Vertical loop piping shall be filled with water prior to inserting into bore. Loop shall be pressure tested after insertion and prior to connecting to manifold.

E. After connection to the vertical loop piping and prior to backfilling, each lateral shall be filled with water and pressure tested.

F. Results of all tests shall be recorded and supplied to the Engineer upon completion of the project.

G. All final tests performed on the completed loop field shall be witnessed by and signed by the Engineer. Provide minimum of 2 working days advance notice to the Engineer prior to testing.

H. Grouting: Vertical bore holes shall, as a minimum, be grouted in adherence with all state and local requirements and with the guidelines of NGWA. Since settling of the grouting material may occur after the initial grouting, Contractor shall monitor each bore hole and add Cementitious Flow Fill as required.

I. Provide and use temporary casings to support unstable soils. All practical measures shall be taken to remove casing. If left in place, maintain minimum of 6" clearance to horizontal piping.

3.4 BACKFILL

A. Place sand bed in bottom of trench prior to installation of horizontal piping to form level surface. Additional sand bedding shall be placed between all horizontal piping to form separation indicated on drawings.

B. Sand backfill around geothermal piping as indicated on drawings shall be environmentally clean sand.

C. Detectable Warning Tape shall be of the type specifically manufactured for marking and locating underground geothermal piping. The tape shall be installed at a depth of 18 inches below finished grade unless otherwise shown. Tape shall be installed on both sides of all horizontal trenches, as well as directly above the pipe if the trench is greater than 3’ wide. The tape shall be acid and alkali resistant polyethylene film. Tape color shall be yellow or silver and shall bear a continuous printed inscription describing the service. Tape shall have integral wires, foil backing, or other means to enable detection by a metal detector when the tape is buried up to 3 feet deep. The metallic core shall be encased in a protective jacket or provided with other means to protect it from corrosion.

3.5 ADJUSTMENTS AND CLEANING

A. Flushing and Purging:

1. Configure flushing/purging unit as recommended by IGSHPA.
2. Flush lines and appurtenances as required for removing all dirt and contaminants within the piping system with potable water until no dirty water appears at outlet.
3. Purge air from system, or sections of system, by maintaining minimum velocity of 2 feet per second through all pipes. Purge until no air bubbles are observed leaving the system.
4. Notify Engineer minimum 2 days before flushing operation.
5. Utilize a portable temporary purging unit consisting of the following:

    a. High volume, high head purge pump capable of maintaining the required purge velocity in all sections of the pipe.
    b. Open reservoir with inlet and outlet valves and pressure gauge
    c. Filter assembly with bypass
    d. Flow meter
    e. Pressure gauge
    f. Connecting piping
    g. Connecting hoses

6. Using a purge pump and the procedures recommended by IGSHPA, flush and purge each ground heat exchanger system at 2 fps flow velocity until free of air,

dirt, and debris. Perform the flushing and purging operation on each group of loops at the indoor valved manifold.

7. Cleanliness shall be demonstrated by passing the fluid through a 50 micron filter for a period of time that would equate to the entire volume of fluid passing through the filter five times. There shall be no significant particulate material visible to the naked eye.

B. Pressure Testing

1. Utilizing the purging unit and the procedures recommended by IGSHPA, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate the blockage using the manufacturer's recommendation, remove the blockage, then purge and conduct the pressure and flow test again until all portions of the system are free-flowing.
2. All pressure testing shall be performed on systems filled with water only. Air may be used to "top-off" and pressurize the water filled systems.
3. Any failures in pressure testing will require investigation and corrective measures that are to be approved by the Engineer. After measures have been taken, another pressure test must be conducted.
4. After successful completion of all required and witnessed testing, the entire loop field shall be sterilized.
5. Pressure Testing shall be done in accordance with ASTM F2164 "Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure". Incorporating the following elements:

    a. Maintain 100 psi for 4 Hours, adding fluid as necessary.
    b. Reduce pressure by 10 psi and begin 1 hour testing period, during which no fluid may be added.
    c. If pressure drops by more than 5 psi at the end of 1 hour, test is deemed a failure and corrective action must be taken to locate and repair leak.

C. Sterilization

1. Before the system may be used, sterilize by circulating water to which a sterilizing agent has been applied, at a rate giving 50 PPM of chlorine, as determined by a residual chlorine test.
2. After lines have been filled for a period of three (3) hours, test for residual chlorine shall show not less than 5 PPM. If less than 5 PPM is indicated, drain and flush out the lines and repeat sterilization treatment until tests indicate at least 5 PPM of residual chlorine after three (3) hours.
3. Flush lines out until all traces of chemical have been removed to the extent of 0.2 PPM maximum chlorine.

D. Reports

1. The following reports shall be submitted to the Engineer for information.

a. As-built drawings.

END OF SECTION 23 81 47