SECTION 13610

HEATING, FLAT-PLATE, SOLAR COLLECTORS

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: Liquid-type, medium-temperature, glazed, heating, flat-plate, solar collectors, accessories, and mountings.

1.3 DEFINITIONS

A. FSEC: Florida Solar Energy Center.

B. SRCC: Solar Rating and Certification Corporation.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for solar collectors.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For solar collectors.

1. Include plans, elevations, sections, and mounting 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.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of solar collector, certifying compliance with SRCC OG-100.

B. Sample Warranty: For manufacturer's special warranty.

1.6 QUALITY ASSURANCE

A. Collector Certification: Certified by FSEC and SRCC.

B. Manufacturer and collector model shall be listed in "Directory of SRCC Certified Solar Collector Ratings."

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace solar collectors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hail Resistance: Able to withstand 1-inch diameter hail.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products by one of the following:
1. Solene Solar Hot Water Systems.
2. Sun Earth Inc.
3. Viessmann Manufacturing Company Inc.

2.3 COLLECTORS

A. Enclosure: Extruded anodized aluminum.

1. Finish: Black.

B. Back Sheet: Aluminum sheet

C. Insulation: Polyurethane foam insulation.

1. Minimum Thermal Resistance (R-value): R-7.5 on the back and R-5 on the sidewalls.

D. Absorber Plate: Blue sputtered coating on copper fins.

E. Header and Absorber Tubes: Copper, ½" NPS risers to a 1" NPS manifold.

F. Glazing:

1. Glazing Materials: Single-sheet, low-iron, tempered glass with textured finish on outside surface.
2. Gaskets and Grommets: UV-resistant EPDM gaskets with molded corners and extruded silicone grommets.
3. Continuous secondary silicone seal between the glass and enclosure.

G. Mounting Frame:

1. Fabricated to withstand wind loads of up to 130 mph (210 km/h) with no separation of the collector from the frame or the frame from the structure.
2. Material: Extruded aluminum.
3. Profile: High angle, 60 degrees.
4. Fasteners: Stainless steel.

H. Collector Certification: Certified by FSEC and SRCC.

2.4 CONTROLS

A. Comply with requirements in Section 15486.1 "Solar Water Heating Equipment."

2.5 CAPACITIES AND CHARACTERISTICS

A. Area:

1. Gross: 39 sq. ft.

B. Dry Weight: 137 lbs.

C. Fluid Type: Water

D. Fluid Capacity: 1.2 gal.

E. Test Pressure: 232 psi.

F. Maximum Operating Temperature: 250 F.

G. SRCC Certified Performance Rating:

1. Clear Day at 2000 Btu/sq. ft. per Day (23 MJ/sq. m per Day): 25 MBH/per panel per day
2. Mildly Cloudy Day at 1500 Btu/sq. ft. per Day (17 MJ/sq. m per Day): 14 MBH/per panel per day.
3. Cloudy Day at 1000 Btu/sq. ft. per Day (11 MJ/sq. m per Day): 4 MBH/per panel per day.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for solar-collector piping to verify actual locations of piping connections before solar-panel installation.

C. Examine walls and roofs for suitable conditions where solar collector will be installed.

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

3.2 SOLAR-COLLECTOR INSTALLATION

A. Comply with manufacturer's written instructions for collector mounting and installation.

B. Install the collector according to ASHRAE's "Active Solar Heating Systems Installation Manual."

C. Install low-voltage wiring from the sensor to the energy-management panel.

D. Mount the collector frame support feet to the structural support steel using stainless-steel bolts. Attach each pair of legs using two bolts for each.

E. Place high-temperature-resistant covers over the header to prevent contaminants from entering the headers.

F. Coat the controller's sensor with a layer of thermal paste and insert into the collector sensor port to full depth. Apply a silicone sealant around the entire perimeter of the sensor where it enters the collector. Completely cover the opening with insulation to prevent water ingress. Only use high-temperature-rated (minimum 395 deg F) sensors and cabling.

G. After connecting the inlet and outlet of the collectors to the system, purge the system of all air.

H. Install collectors with not less than minimum space for access and service as recommended by solar-collector manufacturer.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 15181 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to solar collectors, allow space for service and maintenance.

C. Install flexible connections on piping between collectors installed in series.

D. Install ball valve and union at inlet and outlet of solar collectors. Comply with requirements in Section 15110 "Valves" for materials and installation requirements for ball valves and unions.

E. Connect solar collectors to lightning protection system. Comply with requirements in Section 13100 "Lightning Protection."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify tilt angle, mounting, fluid concentrations, and collector array arrangement.

3.5 ADJUSTING

A. Adjust tilt angle per design requirement and adjust the collector balance valve to provide the design flow.

END OF SECTION 13610

SECTION 15083

HVAC INSULATION

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. All sections of Division 15 and 16 apply to this section.

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Calcium silicate.
   b. Flexible elastomeric.
   c. Mineral fiber.
   d. Polyisocyanurate.
2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied jackets.
10. Tapes.
11. Securements.
12. Corner angles.

1.3 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 deg F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 deg F.

D. Thermal Resistivity: "r-values" represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogeneous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between

two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.

E. Density: Is expressed in lb/cu.ft.

1.4 SUBMITTALS

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

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:
   a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
   b. Sheet Form Insulation Materials: 12 inches square.
   c. Jacket Materials for Pipe: 12 inches long by NPS 2.
   d. Sheet Jacket Materials: 12 inches square.
   e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. 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.

E. LEED Submittal Credit EQ 4: Submit certification stating tha all adhesives & sealants installed in the building interior shall meet the testing and product requirements of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.

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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Containers for Insulation material, coverings, cements, adhesives and coatings shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, maximum use temperature, and fire hazard index.

B. Protect against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation. Remove any such damaged and wet insulation from site.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

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

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.

1.9 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of preliminary acceptance, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Flexible Elastomeric:
   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2. Mineral-Fiber Blanket Insulation:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite.
   c. Owens Corning; All-Service Duct Wrap.

3. Mineral-Fiber Board Insulation:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series..

4. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is UL tested and certified to provide a 2-hour fire rating. Products:
   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
   d. Thermal Ceramics; FireMaster Duct Wrap.
   e. 3M; Fire Barrier Wrap Products.
   f. Unifrax Corporation; FyreWrap.
   g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

5. Mineral-Fiber, Preformed Pipe Insulation:
   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000 Pipe Insulation.
   d. Owens Corning; Fiberglas Pipe Insulation.

6. Mineral-Fiber, Pipe and Tank Insulation:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.

c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

7. Polyisocyanurate:
   a. Apache Products Company; ISO-25.
   b. Dow Chemical Company (The); Trymer.
   c. Duna USA Inc.; Corafoam.
   d. Elliott Company; Elfoam.

8. Fire-Rated Blanket:
   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
   d. 3M; Fire Barrier Wrap Products.

9. Mineral-Fiber Insulating Cement:
   a. Insulco, Division of MFS, Inc.; Triple I.
   b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

10. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement:
    a. Insulco, Division of MFS, Inc.; SmoothKote.
    b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
    c. Rock Wool Manufacturing Company; Delta One Shot.

11. Polyisocyanurate,Adhesive:
    a. Childers Products, Division of ITW; CP-96.
    b. Foster Products Corporation, H. B. Fuller Company; 81-33.

12. Flexible Elastomeric and Polyolefin Adhesive:
    a. Aeroflex USA Inc.; Aeroseal.
    b. Armacell LCC; 520 Adhesive.
    c. Foster Products Corporation, H. B. Fuller Company; 85-75.
    d. RBX Corporation; Rubatex Contact Adhesive.

13. Mineral-Fiber Adhesive:
    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.

14. ASJ Adhesive, and FSK Adhesive:
    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80..

15. PVC Jacket Adhesive:
    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. Speedline Corporation; Speedline Vinyl Adhesive.

16. Vapor-Barrier Mastic:

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Vimasco Corporation; 749.

17. Lagging Adhesives:
    a. Childers Products, Division of ITW; CP-52.
    b. Foster Products Corporation, H. B. Fuller Company; 81-42.
    c. Vimasco Corporation; 136.

18. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products:
    a. Childers Products, Division of ITW; CP-76.
    b. Foster Products Corporation, H. B. Fuller Company; 30-45.
    c. Pittsburgh Corning Corporation; Pittseal 444.
    d. Vimasco Corporation; 750.

19. Metal Jacket Flashing Sealants:
    a. Childers Products, Division of ITW; CP-76-8.
    b. Foster Products Corporation, H. B. Fuller Company; 95-44..
    c. Vimasco Corporation; 750.

20. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
    a. Childers Products, Division of ITW; CP-76.

21. PVC Jacket:
    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto PVC Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.

22. Metal Jacket:
    a. Childers Products, Division of ITW; Metal Jacketing Systems.
    b. PABCO Metals Corporation; Surefit.
    c. RPR Products, Inc.; Insul-Mate.

23. ASJ Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    b. Compac Corp.; 104 and 105.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

24. FSK Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    b. Compac Corp.; 110 and 111.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
    d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

25. PVC Tape:
    a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    b. Compac Corp.; 130.
    c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.

d. Venture Tape; 1506 CW NS.

26. Bands:
    a. Childers Products; Bands.
    b. PABCO Metals Corporation; Bands.
    c. RPR Products, Inc.; Bands.

27. Insulation Pins and Hangers:
    a. AGM Industries, Inc.; CWP-1.
    b. GEMCO; Cupped Head Weld Pin.
    c. Midwest Fasteners, Inc.; Cupped Head.
    d. Nelson Stud Welding; CHP
28. Wire:
    a. C & F Wire.
    b. Childers Products.
    c. PABCO Metals Corporation.
    d. RPR Products, Inc.

2.2 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain 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. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

G. 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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is UL tested and certified to provide a 2-hour fire rating. Products:

J. Mineral-Fiber, Preformed Pipe Insulation:

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2,. 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.

L. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
   a. Pipe Applications: ASJ
   b. Equipment Applications: ASJ

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

2.4 INSULATING CEMENTS

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

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

2.5 ADHESIVES

A. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.

B. 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.

C. Cellular-Glass, Phenolic and Polyisocyanurate,Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

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

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.6 MASTICS

A. All Mastics (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F .
3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
4. Color: White.

2.7 LAGGING ADHESIVES

A. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.

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

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
2. Service Temperature Range: Minus 50 to plus 180 deg F .
3. Color: White.

2.8 SEALANTS

A. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.

B. 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.

C. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.9 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.10 FIELD-APPLIED JACKETS

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

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM 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. Adhesive: As recommended by jacket material manufacturer.
2. Color: Color-code jackets based on system. .
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
4. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Sheet and roll stock ready for shop or field sizing.

b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 2.5-mil- thick Polysurlyn
e. Factory-Fabricated Fitting Covers:
    1) Same material, finish, and thickness as jacket.
    2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    3) Tee covers.
    4) Flange and union covers.
    5) End caps.
    6) Beveled collars.
    7) Valve covers.
    8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.11 TAPES

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

1. Width: 3 inches.
2. Thickness: 11.5 mils
3. Adhesion: 90 ounces force/inch in width. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. 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. Width: 3 inches.
2. Thickness: 6.5 mils .
3. Adhesion: 90 ounces force/inch in width. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. 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. Width: 2 inches.

2. Thickness: 6 mils
3. Adhesion: 64 ounces force/inch in width. All Adhesives & Sealants (LEED EQ 4): All adhesive and sealants installed in the building interior shall meet the testing and product requirements of of the California Department of Health Services Standard for the Testing of Volatile Organic Emissions From Various Sources Using Small Scale Environmental Chambers, including 2004 addenda.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.020 inch thick,3/4 inch wide with wing or closed seal..
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
    b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation 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.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and prepare surfaces to be insulated. Remove materials that will adversely affect insulation application. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing, if any. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

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, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system 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. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

L. 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. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

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

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

O. 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.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

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

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

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.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. For Hot Water systems, fabricate boxes from galvanized steel, at least 0.050 inch thick.
3. For Dual Temperature, Chilled Water or Cold Water Systems, fabricate boxes from stainless steel at least 0.050 inch thick.
4. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles. Coordinate with drawings for insulation at locations of pipe expansion.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

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

D. Install removable insulation covers at locations indicated on drawings. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches , place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. 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.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface.

Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. 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.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches .

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.9 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. 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.

B. Where Stainless Steel 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.

3.11 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 7 Section "Through-Penetration Firestop Systems."

3.12 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ exposed to view only: Paint jacket with paint system identified below and as specified in Division 9 painting Sections. Coordinate with Architect.

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

3.13 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections..

B. Tests and Inspections:

1. Inspect ductwork, 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 for each duct system defined in the "Duct Insulation Schedule, General" Article.
2. 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 for each type of equipment requiring insulation for this project. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, 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 three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers,

two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Architect may reject all work if sample work is found to be defective.

3.14 DUCT INSULATION PERFORMANCE , GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, supply and outdoor air.
2. Indoor, concealed return located in non-conditioned space.
3. Indoor, return located in non-conditioned space.
4. Indoor, kitchen hood exhaust.
5. Indoor, exhaust between isolation damper and penetration of building exterior.
6. Outdoor, supply, return and outdoor air.
7. .

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1 2004.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.15 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. INSULATION APPLICATION SCHEDULE
1. General: Abbreviations used in the following schedules include:
   a. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.

B. DUCT SYSTEMS INSULATION SCHEDULE

DUCT LOCATION	OUTSDIE AIR, SUPPLY AIR , EXHAUST AIR (DOWN STREAM OF DAMPER) INSULATION INSTALLED R-VALUE (H-FT^2-°F)/BTU	RETURN INSULATION INSTALLED R-VALUE (H-FT^2-°F)/BTU
EXTERIOR OF BUILDING (NOTE 5,6,7)	6.5	6.5
VENTILATED ATTIC (NOTE 5,7)	6.5	6.5
UNVENTED ATTIC ABOVE INSULATED CEILING (NOTE 5,7)	6.5	6.5
UNVENTED ATTIC W/ ROOF INSULATION (NOTE 1,5,7)	3.5	-
UNCONDITIONED SPACE (NOTE 2,5,6,7)	6.5	6.5
INDIRECTLY CONDITIONED SPACE (NOTE 3,7)	-	-
CEILING CAVITY / SHAFTS / SOFFITS / MECHANICAL SPACES AND ROOMS (NOTE 4,5,6,7)	3.5	-
EXPOSED LOCATIONS WITHIN CONDITIONED SPACE	-	-
BURIED	3.5	-

NOTE 1: INSULATION R-VALUES, MEASURED IN (H X FT^2 X F)/BTU, ARE FOR THE INSULATION AS INSTALLED AND DO NOT INCLUDE FILM RESISTANCE. WHERE EXTERIOR WALLS ARE USED AS PLENUM WALLS, WALL INSULATION SHALL BE AS REQUIRED BY THE MOST RESTRICTIVE CONDITION OF ASHRAE 90.1-2004 SECTION 5 OR 6.4.4.2. INSULATION RESISTANCE MEASURED ON A HORIZONTAL PLANE IN ACCORDANCE WITH ASTM C518 AT A MEAN TEMPERATURE OF 75F AT THE INSTALLED THICKNESS.

NOTE 2: INCLUDING CRAWL SPACES (BOTH VENTILATED/NON-VENTILATED), FRAMED CAVITIES IN WALLS, FLOOR AND CEILING ASSEMBLIES WHICH (A) SEPARATE

CONDITIONED SPACE FROM UNCONDITIONED SPACE OR OUTSIDE AIR, AND (B) ARE UNINSULATED ON THE SIDE FACING AWAY FROM CONDITIONED SPACE.

NOTE 3: RETURN AIR PLENUMS WITH OR WITHOUT EXPOSED ROOFS ABOVE.

NOTE 4: CAVITY CONTAINED WITHIN THE INSULATED BUILDING ENVELOPE.

NOTE 5: VAPOR BARRIER REQUIRED.

NOTE 6: FIELD APPLIED JACKET (STAINLESS STEEL FOR EXTERIOR APPLICATIONS, PVC FOR INTERIOR EXPOSED LOCATIONS).

NOTE 7: PROVIDE MINERAL FIBER BOARD WITH FIELD APPLIED JACKET (SS EXTERIOR, ALL SERVICE INTERIOR) IN EXPOSED LOCATIONS IN LIEU OF MINERAL FIBER BLANKET.

C. KITCHEN EXHAUST DUCTS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
FIRE RATED BLANKET		NOTE 1	NO	NONE
CALCIUM SILICATE	BOARD	NOTE 1	NO	(SS) Exposed Duct

NOTE 1: AS REQUIRED FOR A 2 HR RATING.

D. CONVECTION OVEN AND DISHWASHER EXHAUST DUCTS

MATERIAL	FORM	THICKNESS IN INCHES	VAPOR BARRIER REQ'D	FIELD-APPLIED JACKET
GLASS FIBER	BOARD	2	NO	(SS) Exposed Duct
CALCIUM SILICATE	BOARD	2	NO	(SS)
FIRE RATED BLANKET		NOTE 1	NO	NONE

NOTE1: AS REQUIRED FOR A 2 HR RATING.

3.16 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 in paragraphs below that are not factory insulated.

C. Chillers: See Chiller Specification Section for insulation of cold surfaces of Chillers.

D. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

E. Steam-to-hot-water converter insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. Stainless steel jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. Stainless steel jacket.

F. Chilled-water pump insulation shall be the following:
1. Mineral-Fiber Board**:** 2 inches thick and 3-lb/cu. ft. nominal density. Vapor barrier.

G. Dual-service heating and cooling pump insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick an 3-lb/cu. ft. nominal density. Vapor barrier.

H. Heating-hot-water pump insulation shall be one of the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

I. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft**.** nominal density.PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

J. Chilled-water expansion/compression tank insulation shall be:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

K. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket

L. Heating-hot-water expansion/compression tank insulation shall be one of the following:

1. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. PVC jacket.

M. Chilled-water air-separator insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

N. Dual-service heating and cooling air-separator insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch thick. Vapor barrier and PVC jacket.
2. Mineral-Fiber Pipe and Tank: 1 inch thick. Vapor barrier and PVC jacket.

O. Heating-hot-water air-separator insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft**.** nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

P. Deaerator insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

Q. Steam condensate tank and receiver insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft**.** nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

R. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
2. Mineral-Fiber Pipe and Tank: 2 inches thick.

S. Piping system filter-housing (side stream filter) insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density. PVC jacket.
2. Mineral-Fiber Pipe and Tank: 2 inches thick. PVC jacket.

3.17 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 PIPING INSULATION SCHEDULE

A. General:

B. Abbreviations used in the following schedules include:

1. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.
2. Pipe Sizes: NPS - Nominal Pipe Size.

C. Minimum HVAC pipe insulation thickness table:

NON-LEED PROJECTS	**FLUID TEMPERATURE RANGE (°F)**	**INSULATION TYPE AND FIELD-APPLIED JACKET**			**PIPE SIZE AND INSULATION THICKNESS (INCHES)[5][6]**					
HEATING SYSTEMS[1] (Steam and Hot Water)		GLASS FIBER	POLYISO-CYANURATE	FLEXIBLE ELASTOMERIC		< 1"[4]	1" to < 1-1/2"	1-1/2" to < 4"	4" to 6"	8" and Larger
High pressure/temperature	306-450	X[7]				2-1/2	3	3	4	4-1/2
Medium pressure/temperature	251-305	X[7]				2	2-1/2	3	3	3
Low pressure/temperature	201-250	X[7]				1-1/2	1-1/2	2	2	2
Low temperature	106-200	X[7]		X		1	1	1-1/2	1-1/2	1-1/2
Steam Condensate (for feed water)	Any	X[7]		X		1	1-1/2	2	2	2
COOLING SYSTEMS[1]										
Chilled water, refrigerant and brine	40-60	X[2][7][8]	X[2][3][8]	X[7][8]		1/2	3/4	1	1	1
	Below 40	X[2] [7][8]	X[2][3][8]	X[7][8]		1	1-1/2	1-1/2	1-1/2	1-1/2

Notes:

1. Glass fiber insulation only for hydronic piping
2. (P), (A) or (SS) Field-Applied Jacket on outdoor installations, exposed and concealed
3. For outdoor use only
4. Piping insulation is not required between control valve the controlvalve and coil on runouts when the control valve is within 4ft of the coil and the pipe size is 1" or less.
5. For piping exposed to outdoor air, increase insulation thickness by 1 inch
6. Insulation thickness is based on insulation having a thermal conductivity of 0.22 to 0.25 BTU-inch/(h-ft^2°F) on a flat surface at a mean temperature of 75F.

See Chicago Energy Conservation Code for insulation thickness adjustements due to different resistivity values.

7. Not used.
8. Vapor barrier.

3.19 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

3.20 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches

1. Stainless Steel, Type 304, Smooth 2B Finish: 0.016 inch thick.

C. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Stainless Steel, Type 304, Smooth Finish: 0.020 inch thick..

D. Piping, Exposed

1. Stainless Steel, Type 304 Smooth 2B Finish 0.016 inch thick.

3.21 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

3.22 CLEANING – NOT APPLICABLE

3.23 CONTRACTOR STARTUP AND REPORTING – NOT APPLICABLE

3.24 DEMONSTRATION AND COMMISSIONING – NOT APPLICABLE

END OF SECTION 15083

SECTION 15189

HVAC WATER TREATMENT

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. All sections of Division 15 and 16 apply to this section.

1.2 SUMMARY

A. This Section includes the following HVAC water-treatment systems:

1. Closed hydronic hot water, chilled water, geothermal, dual temperature systems (both water and glycol).
2. Open hydronic condenser water systems.
3. Steam heating systems.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems (both water and glycol), including hot-water heating, chilled water, geothermal, dual-temperature water, shall have the following water qualities:

1. pH: Maintain a value within 8.5 to 10.2.
2. "P" Alkalinity: Record value and include in test report.
3. Boron: Adjust value as needed to buffer pH to range indicated in 1.4.C.1. Record final value in test report.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. Conductivity = 3500 µS/cm maximum.

6. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
7. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
    c. Nitrate Reducers: Maintain a maximum value of 100organisms/ml.
    d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

D. Steam Boiler and Steam Condensate:

1. Steam Condensate:

    a. pH: Maintain a value within 7.8 to 8.4.
    b. Total Alkalinity: Maintain a value within 5 to 50 ppm.
    c. Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
    d. Soluble Copper: Maintain a maximum value of 0.20 ppm.
    e. TDS: Maintain a maximum value of 10 ppm.
    f. Total Hardness: Maintain a maximum value of 2 ppm.

2. Steam boiler operating at 15 psig and less shall have the following water qualities:

    a. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
    b. TDS: Maintain a value within 600 to 3000 ppm.

3. Steam boiler operating at more than 15 psig shall have the following water qualities:

    a. "OH" Alkalinity: 200 to 400 ppm.
    b. TDS: Maintain a value within 600 to 1200 ppm to maximum 30 times water TDS.

E. Open hydronic systems, including condenser water, shall have the following water qualities:

1. pH: Maintain a value within 8.0 to 9.1.
2. "P" Alkalinity: Maintain a maximum value of 50 ppm.
3.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. Conductivity: 1500 µS/cm.
6. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm
7. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

8. Polymer Testable: Maintain a minimum value within 10 to 40.

F. Passivation for Galvanized Steel (cooling tower applications): For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.
2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm, pH shall not exceed 8 as the controlling limit.

1.5 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TDS/conductivity controllers.
6. Biocide feeder timers.
7. Chemical solution tanks.
8. Injection pumps.
9. Chemical test equipment.
10. Chemical material safety data sheets.
11. Water softeners.
12. Multi-cartridge-type side stream filters.
13. Centrifugal separators.
14. Glycol test kit.
15. Pressure Fill Systems
16. Glycol.
17. Copy of project technicians qualifications/certificates.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, sequence of operations and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: Power and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For sensors, injection pumps, water softeners, water filtration units, and controllers to include in emergency, operation, and maintenance manuals. Provide two weeks prior to training.

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

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

F. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.

2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report (Open condenser water systems only): Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section. The project technicians shall be Certified Water Technologists (CWT) in good standing certified by the AWT, or have similar training and experience qualifications.

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.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service (all labor) program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for chilled-water piping, heating hot-water piping, dual temperature-water piping, geothermal water piping, steam and condensate piping, condenser-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Initial water analysis (conducted on the owner's premise) and HVAC water-treatment recommendations. Written report of the findings to be left with the owner and a copy of such report to be forwarded to the commissioning agent and consulting engineer.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required glycol/chemical treatment prior to operation.
3. Periodic field service and consultation. Include all work as described in sections 3.8.D and E. Also, check for proper operation of all pumps, controllers, meters and sensors. Calibrate sensors as needed. Check chemical tank levels and inventory, and arrange chemical deliveries well in advance of needs.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.
7. Train owner's operating personnel with the operation and adjustment of each piece of equipment / system, care and handling of treatment chemicals, and water test control procedures including basic water chemistry and the importance of water treatment.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Earthwise Environmental
2. H-O-H Chemicals, Inc.
3. Nalco Company.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT (For Use In Closed Piping Systems)

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 5 gal.
2. Minimum Working Pressure: 125 psig.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, tantalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded or flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow. Hardwired to both the chemical controller and the building automation system.

B. Water Meter:

1. AWWA C701, turbine-type, tantalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded or flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow. Hardwired to both the chemical controller and the building automation system.

C. Inhibitor Injection Timers (Open Systems):

1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Building automation system alarm dry contacts.
9. Audible alarm and light.

D. pH Controller (Open Systems Requiring Acid Injection for pH Control):

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low pH alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.
8. Building automation system alarm dry contacts.
9. Audible alarm and light.
10. Provide a backup safety timer for systems requiring acid injection that will shut off the acid pump after a fixed time, to protect against pH controller failure.

E. Conductivity Controller (Open Systems – Steam Boilers, Cooling Towers, Etc.):

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High or low conductance alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Building automation system alarm dry contacts.
10. Audible alarm and light.
11. Bleed Valves:

    a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

F. Biocide Feeder Timer (Open Systems – Cooling Towers):

1. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two different formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.
10. Building automation system alarm dry contacts.
11. Audible alarm and light.

G. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 120 gal.

H. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 15 Section "Motors."

I. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

J. Pressure Fill System: Provide a complete factory packaged automatic glycol / make-up water fill system unit per system as manufactured by Bell & Gossett (GMU) or equal by Taco, Armstrong as scheduled. The unit shall consist of a base, 55 gallon tank (steel or polyethylene) with removable lid, fill vent opening, observable fluid level indicator scale (gallons), Y-strainers, isolation valves, triple combination shut off – Non slam check – calibrated balance valves, open drip proof motor, pump, expansion tank, motor contactor, pressure controls, interconnecting piping, low level safety shut down, remote alarm contacts, indicator light, fill valve (automatic for water systems, manual for glycol systems), discharge pressure gauge, discharge line pressure reducing valve, isolation valves, pressure gauge and single point power connection. Provide float type fill valve when used in non-glycol systems.

K. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.4 STAINLESS-STEEL PIPES AND FITTINGS

A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.

B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig SWP and 600-psig CWP ratings.

2.5 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, Conductivity, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems, and glycol test kit for closed loop heating/cooling/dual temperature systems, and other test equipment as required by the water treatment supplier.

B. Sample Cooler (Steam Boilers):

1. Tube: Sample.

a. Size: NPS 1/4 tubing.
b. Material: ASTM A 666, Type 316 stainless steel.
c. Pressure Rating: Minimum 2000 psig.
d. Temperature Rating: Minimum 850 deg F.

2. Shell: Cooling water.

a. Material: ASTM A 666, Type 304 stainless steel.
b. Pressure Rating: Minimum 250 psig.
c. Temperature Rating: Minimum 450 deg F.

3. Capacities and Characteristics:

a. Tube: Sample.

1) Flow Rate: 0.25 gpm.
2) Entering Temperature: 400 deg F.
3) Leaving Temperature: 88 deg F.
4) Pressure Loss: 6.5 psig.

b. Shell: Cooling water.

1) Flow Rate: 3 gpm.
2) Entering Temperature: 70 deg F.
3) Pressure Loss: 1.0 psig.

C. Portable Glycol Test Kit Assembly: Kit shall include sample container, chart, carrying case, instructions, all components required to determine the type of glycol, % of glycol to water by volume and condition of glycol (contamination) in the field.

D. Corrosion Test-Coupon Assembly: Constructed of 1-inch diameter corrosion resistant material, complete with piping, valves, 0-20 gpm flow meter and control valve, and mild steel and copper coupons. Alternatively, the assembly may be constructed from 1-inch black iron pipe, to provide additional surfaces for corrosion evaluation. The assembly shall be installed in the vertical plane, properly supported, with water flow from the bottom to the top of the assembly.

1. Two-station rack for closed-loop systems.
2. Four-station rack for open systems.

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals (Steam Boiler Systems):

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

C. Glycol (Closed Systems):

1. Propylene Ethylene Glycol: HVAC grade containing corrosion inhibitors and environmental stabilizer additives for mixing with softened water. Softened water shall be used to dilute the glycol to 30 percent by volume in the system. Industrial/automotive/marine/raw glycol shall not be used in any HVAC application.

2.7 HVAC MAKEUP WATER SOFTENER (Steam Boiler Systems)

A. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

B. Mineral Tanks:

1. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
2. Pressure Rating: 100 psig minimum.
3. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F.
4. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
5. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
6. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
7. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.

C. Controls: Automatic; factory mounted on mineral tanks and factory wired.

1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
4. Means of manual operation of pilot-control valve if power fails.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

    a. Slow opening and closing, nonslam operation.
    b. Diaphragm guiding on full perimeter from fully open to fully closed.
    c. Isolated dissimilar metals within valve.
    d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
    e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
    f. Sampling cocks for soft water.

6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons, and automatically resets after regeneration to preset total in gallons for next service run. Include alternator to regenerate one mineral tank with the other in service.

D. Brine Tank: Combination measuring and wet-salt storing system.

1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch thick; or molded PE a minimum of 3/8 inch thick.
2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
3. Size: Large enough for at least four regenerations at full salting.

E. Factory-Installed Accessories:

1. Piping, valves, tubing, and drains.
2. Sampling cocks.
3. Main-operating-valve position indicators.
4. Water meters.

F. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.

G. Capacities and Characteristics:

1. As scheduled.

2.8 FILTRATION EQUIPMENT

A. Multi-Cartridge (Minimum 4) Type Side Stream Filters (Closed Hydronic Systems):

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

a. PEP Filters, Inc.
b. Cuno
c. Watts

2. Description: Floor-mounting housing with multiple filter cartridges (minimum 4) for removing particles from water.

a. Housing: Stainless steel; designed to separate inlet from outlet and to direct inlet through multiple cartridge-type water filters; with base, feet, or skirt.

1) Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
2) Stainless Steel Housing Pipe Connections NPS 2-1/2 and Larger: Stainless Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
3) Tool free replacement of filters (V-Band Clamp, etc.).
4) Top vent with valve.
5) Bottom drain with valve.
6) Pressure and temperature taps across unit.

b. Multi-Filter Cartridges: Multi-Filter Cartridges shall be wound polypropylene media with a tin core, 0-20 micron rating, and a maximum temperature rating of 200°F sized to properly fit the filter vessel. The minimum flowrate shall be the greatest of 5% of system pump flowrate/filtration of the entire system volume every 4 hours/25 GPM. Pressure drop through clean filters at flowrate above shall not exceed 2 psig. Filter cartridges shall be furnished in a quantity sufficient for six (6) complete changes of the filter vessel. Filter cartridges shall be changed when the pressure drop across the filter vessel exceeds 6 psi.

B. Centrifugal Separators (Cooling Tower Applications):

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

    a. LAKOS; a div. of Claude Laval Corporation.
    b. PEP Filters, Inc.
    c. Puroflux Corporation.

2. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.
3. Housing: With manufacturer's proprietary system of baffles and chambers.

    a. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
    c. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
    d. Collection Chamber: Designed to hold separated particles.
    e. Outlet: Near top of unit.
    f. Purge: At bottom of collection chamber.
    g. Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
    h. Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.

4. Motorized Purge Valve: Plug pattern valve.
5. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
6. Controls: Automatic control of separator purge; factory wired for single electrical connection.

    a. Panel: NEMA 250, Type 4 enclosure.
    b. Separator Purge: Automatic and manual.
    c. TDS Controller Interlock: Open separator purge valve with bleed-off control.

7. Support: Skid mounting
8. Capacities and Characteristics:

    a. Separator Design:

        1) Water Flow Rate: 5% of system pump flow in gpm.
        2) Maximum Pressure Loss: 5 psig.
        3) Separator Efficiency: 98 percent.
        4) Particle Specific Gravity: 1.8.
        5) Particle Size: 20 microns.

    b. Housing:

        1) Material: Stainless steel.
        2) Pressure Rating: 125 psig.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install water testing equipment on wall near water chemical application equipment.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Provide sensors and injectors in piping circuits. Coordinate locations with piping contractor.

E. Provide one portable glycol test kit assembly and instructions.

F. Provide 30% by volume inhibited glycol mix (propylene – new systems or where propylene is currently used in existing system, ethylene – in existing systems where ethylene is currently installed) in all closed hydronic systems.

G. Bypass Feeders: Install in all closed hydronic systems, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps.
4. Install a full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.
6. Install per drawings and details.

H. Multi-Cartridge Side Stream Filter: Install in all closed hydronic systems, and equipped with the following:

1. Install multi-cartridge side stream filter in a bypass circuit around circulating pumps.
2. Install a full-port ball isolation valves on inlet, outlet, vent and drain below feeder inlet.
3. Install a swing check on inlet after the isolation valve.
4. Install on 4” high equipment pad.
5. Install per drawings and details.

I. Centrifugal Separator: Install in all open hydronic systems (condenser water), and equipped with the following:

1. Install centrifugal separator in a bypass circuit around circulating pumps.
2. Install a full-port ball isolation valves on inlet, outlet, and vent.
3. Install a motorized purge valve at the outlet and pipe to floor drain.
4. Install on 4” high equipment pad.

5. Install per drawings and details.
6. Coordinate interlock of purge operation with building automations system.

J. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install makeup water softener.
2. Install water meter in makeup water supply. Coordinate totalization signal with building automation system.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

4. Install test equipment and furnish test-kit to Owner.
5. Install TDS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install inhibitor injection timer with injection pumps and solution tanks.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

K. Install pressure fill units on all closed hydronic systems and include the following:

1. Install water meter in makeup water supply. Coordinate totalization signal with building automation system.
2. Coordinate alarm signal tie in to building automation system.
3. Provide pressure regulator set at the difference in height (in psig) between the discharge of the pressure regulator to the highest point in the system plus 5 psig.
4. Install per the drawings/details and as required by the manufacturer.

L. Install automatic chemical-feed equipment for condenser water and include the following:

1. Install water meter in makeup water supply. Coordinate totalization signal with building automation system.
2. Install water meter in blowdown drain line. Coordinate totalization signal with building automation system.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection

4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps.
5. Install TDS controller with sensor and bleed valves.

a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install pH sensor and controller with injection pumps and solution tanks.

a. Injector pumps shall operate to maintain required pH.

7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.

a. Injection pumps shall operate to feed biocide on an alternating basis.

3.3 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water-testing sets on wall adjacent to water softeners.

3.4 CONNECTIONS

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

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 15 Section "Basic Mechanical Materials and Methods."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 15 Section "Valves."

E. Refer to Division 15 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 16 Sections for connecting electrical equipment.

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

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

3.5 STEAM BOILER BOIL-OUT PROCEDURE

A. Introduction of Cleaner:

1. Determine water capacity and calculate chemical volume of cleaner requirements. Volume of cleaner shall be per manufacturer's requirements. Add solution proportionately to the boiler as it is being filled. If not, pour solution through vent or manhole.

B. Boil-out Procedure:

1. Fire boiler gradually and close all vents when steam appears.
2. Build pressure to 50% of normal working pressure.
3. Continue boil-out for a minimum of 48 hours. During the entire boil-out period, blow the boiler from all openings at least once every 8 hours, blowing first from the surface blow and progressing to lower points on the boiler.
4. Replenish blow-down losses with cleaner chemical treated water to maintain desired cleaner strength in boiler.

C. Flushing: At end of boil-out, cool boiler slowly, drain and flush with high pressure hose. Inspect boiler for cleanliness.

D. Acceptance: Upon completion and verification of flushing, all work records covering the boil-out operation will be submitted to the Owner's representative.

3.6 CLEANING

1. General: Prior to acceptance by the owner, all grease, dirt, oil, and metallic oxides shall be removed from each closed recirculating and open cooling tower system. Each system in its entirety shall be cleaned (including all attached existing systems). Equipment shall be provided to meter the water, filter system water, mix and inject the cleaning solution into the system. Mechanical Contractor shall inform Water Treatment Contractor of all system materials of construction, to insure chemical cleaner compatibility. Circulate cleaning agent, wetting all metal surfaces and flush from the system at completion. Supervision shall be provided by water treatment contractor.

2. Procedure:

a. Open all valves in a manner to ensure substantial flow through all components of the system.
b. The system shall be filled through a suitable water meter to determine total water capacity, taking care to bleed all air.
c. Chemical liquid cleaner shall be added to the system per the chemical manufacturer's requirements. The Chemical Water Treatment Contractor shall verify cleaner strength.
d. Hot Water/Dual Temperature Water Systems shall be heated to 160 - 180 degrees F and circulated for 24 hours. Chilled Water/Condenser Water/Geothermal Water Systems shall be circulated for 48 hours.
e. During the cleaning period, system water shall be circulated through the entire system. Where systems contain redundant pumps, both/all pumps shall operate at

full speed to maximize velocity in the piping system. Mechanical Contractor / Chemical Treatment Contractor shall insure that all small orifices (control valves, strainers, etc.) and branches remain free of debris. Utilize the system side stream filter or centrifugal separator for solids removal during the cleaning period. Filter media shall be changed as specified in the Filter Cartridge specifications. Provide additional filter cartridges beyond those specified in Part 2 for the cleaning process.

f. When the cleaning circulation period is complete, the system shall be drained and flushed with fresh water to remove the cleaning solution. Flushing shall continue until the fluid is clear and the total (M) alkalinity of the system water is within fifty (50) PPM of the total alkalinity of the make-up water. Once alkalinity is within stated parameters, clean all strainers. At that point a sampling of 10 locations throughout the system will be selected by the owner's representative (commissioning agent/engineer/architect). If the pipes at the selected locations flow at design flow free of debris and the fluid is clear, then cleaning will be deemed complete. If the flow is restricted in locations or the fluid is not clear, the cleaning process shall be repeated. Include provisions to clean the entire system three times. If the system is not clean after three rounds, notify the owner's representative (commissioning agent/engineer/architect) for further direction.

g. Immediately following completion and verification of flushing, certification records covering the cleaning operation shall be submitted to the owner's representative (commissioning agent/engineer/architect). Records shall include; System volume, cleaner concentration, circulation time, volume of flush water and final alkalinity reading.

h. When cleaning has been completed, each system shall then be chemically treated as provided elsewhere in the specifications. Each system must be filled immediately after cleaning, using chemically-treated water/glycol. All water/glycol added to any system after cleaning must be chemically treated.

3. Chemicals: Grease, dirt, oil and metallic oxides shall be removed from each closed and open water system using a non-foaming, liquid cleaning agent formulated to lift and disperse organic soil, and to chelate alkaline earth metals and metallic oxides. Chemicals shall be chosen so as not to damage any components of the systems.

4. Test Equipment: Provide one Test Cabinet with light, lock, and acid resistant enamel finish, suitable for wall mounting. Cabinet shall be equipped with the necessary test sets for the determination of a complete water analysis, including, but not limited to; alkalinities, hardness, triple range conductivity meter and all tests necessary to control chemical dosages.

3.7 PASSIVATION OF GALVANIZED STEEL (COOLING TOWERS)

1. General: Upon acceptance of condenser water system cleaning and first chemical treatment, add chemical to passivate all galvanized components of the cooling tower system in the 1st 60 days of operation. Maintain pH, Hardness and Alkalinity values as indicated in Part 1 of this specification.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

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

B. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water/glycol (as indicated), and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.
9. Adjust water flow through corrosion coupon assemblies to 8 gpm = 3 ft/sec through 1-inch pipe, or lower flow as required by owner.

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

D. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

E. At one week intervals for five weeks following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Continue testing as above at four-week intervals. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.9 DEMONSTRATION AND COMMISSIONING

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

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining systems/equipment. The training will occur after the startup/cleaning report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training. Training shall be provided in two separate 4 hour sessions. Sessions shall not occur on the same day.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

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

END OF SECTION 15189

SECTION 15486.1

SOLAR WATER HEATING 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. Provide a solar energy system arranged for preheating of domestic water using flat plate liquid solar collectors. Section includes: Solar collector array, storage tank, pumps, automatic controls, instrumentation, interconnecting piping and fittings, domestic potable water heat transfer fluid in a closed loop, heat exchanger, drain-back tank, and accessories required for the operation of the system.

B. Related Sections:

1. Section 15076 "Identification for Plumbing Piping and Equipment".
2. Section 15110 "General-Duty Valves for Plumbing Piping".
3. Section 15140 "Domestic Water Piping".
4. Section 15145 "Domestic Water Piping Specialties".
5. Section 15441 "Domestic Water Pumps".
6. Section 15486 "Fuel-Fired Water Heaters".
7. Section 13610 "Heating, Flat-Plate, Solar Collectors".

1.3 DEFINITIONS

A. FSEC: Florida Solar Energy Center.

B. SRCC: Solar Rating and Certification Corporation.

1.4 SUBMITTALS

A. Product Data:

a. Piping
b. Instrumentation
c. Valves
d. Piping specialties
e. Pumps
f. Solar storage tanks
g. Solar collectors

h. Heat exchangers
i. Compression tanks
j. Solar-boosted domestic water heaters
k. Collector heat transfer fluid

B. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for solar collectors.

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

D. Shop Drawings

1. Solar Energy System.

2. As-Built Drawings:

a. Drawings containing a system schematic; a collector layout and roof plan noting reverse-return piping for the collector array; a system elevation; an equipment room layout; a schedule of operation and installation instructions; and a schedule of design information including collector height and width, and number of collectors to be grouped per bank. Include on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work, including clearances for maintenance and operation. As-built drawings, as specified.

3. Product Data

a. Spare Parts
b. A complete list of equipment and materials, as specified.

E. Solar Energy System

1. Manufacturer's descriptive and technical literature; performance chart and curves; catalog cuts; and installation instructions. Proposed diagrams, instructions, and other sheets, prior to posting. A copy of the posted instructions proposed to be used, including a system schematic, wiring and control diagrams, and a complete layout of the entire system. Include with the instructions, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system, methods of balancing and testing flow in the system, and methods of testing for control failure and proper system operation.

F. Test Reports

1. Inspection and Testing

a. An independent testing agency's certified reports of inspections and laboratory tests, including analysis, position of flow-balancing equipment, and interpretation

of test results. Each report shall be properly identified. Describe test methods used and compliance with recognized test standards.

G. Operation and Maintenance Data

1. Operation and Maintenance Procedures

a. Six (6) copies of operation and six (6) copies of maintenance manuals for the equipment furnished. One complete set prior to performance testing and the remainder upon acceptance. Manuals shall be approved prior to the field training course. Operating manuals shall detail the step-by-step procedures required for system filling, startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, service manual, parts list, and brief descriptions of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, troubleshooting guides, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams of the system as installed.

1.5 QUALITY ASSURANCE

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

B. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

D. Collector Certification: Certified by FSEC and SRCC.

E. Manufacturer and collector model shall be listed in "Directory of SRCC Certified Solar Collector Ratings."

1.6 WELDER QUALIFICATIONS

A. Qualify procedures and welders in accordance with the code under which the welding is specified to be accomplished.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation, and dirt and dust or other contaminants.

1.8 WARRANTY

A. Provide a minimum 10-year warranty against the following: failure of manifold or riser tubing, joints or fittings; degradation of absorber plate selective surface; rusting or discoloration of collector hardware; and embrittlement of header manifold seals. Include in the warranty full repair or replacement of defective materials or equipment.

1.9 SPARE PARTS

A. Submit data for each different item of material and equipment listed, including a complete list of parts and supplies, with current unit prices and source of supply; a list of parts and supplies that are either normally furnished at no extra cost with the purchase of equipment, or specified to be furnished as part of the contract; and a list of additional items recommended by the manufacturer to ensure efficient operation for a period of 120 days.

PART 2 - PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

A. Standard Products

1. Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

B. Nameplates

1. Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

C. Identical Items

1. Items of the same classification shall be identical, including equipment, assemblies, parts, and components.

D. Equipment Guards and Access

1. Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts so located that any person may come in close proximity. High-temperature equipment and piping so located as to endanger personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Provide catwalk, ladder, and guard rails where shown and in accordance with METAL FABRICATIONS Section(s).

E. Special Tools

1. Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.2 PIPING SYSTEM

A. Piping system shall be complete with pipe, pipe fittings, valves, strainers, expansion loops, hangers, inserts, supports, anchors, guides, sleeves, and accessories. System materials shall conform to the following:

1. Copper Tubing

a. ASTM B 88M ASTM B 88, Type K where buried, Type L otherwise. Collector risers Type L.

2. Solder

a. Lead-free solder as required for potable domestic water piping systems.

3. Joints and Fittings for Copper Tubing:

a. Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75M ASTM B 75.

b. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B 828.

c. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62.

d. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

e. Cast bronze threaded fittings shall conform to ASME B16.15.

f. Grooved mechanical joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A 183.

4. Flanges

a. Bronze, Class 125 or 150 as applicable, ASME B16.24.

5. Dielectric Unions and Flanges

a. Unions and flanges shall conform to the requirements of ASME B16.39. Dielectric unions shall have metal connections at both ends suited to match connecting piping. Ends shall be threaded or soldered to match adjacent piping. Dielectric unions shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric unions and flanges shall be suitable for the temperatures, pressures, **[and antifreeze]** encountered.

Dielectric flanges shall meet the performance requirements described herein for dielectric unions.

6. Bronze Gate, Globe, Angle, and Check Valves

   a. MSS SP-110, Type 1 non-slam, spring type, Class 150; As specified in Section 15111 "General Duty Valves for Plumbing Piping".

7. Ball Valves

   a. MSS SP-110, Class 150; As specified in section 15111 "General Duty Valves for Plumbing Piping".

8. Relief Valves, Pressure and Temperature

   a. CSA/AM Z21.22. Pressure relief valves located on the solar collector array upper manifold and on the drain-back tank shall open and discharge the collector fluid into adjacent open-site drain when fluid pressure rises above 125 psig. Pressure and temperature relief valves located on the solar storage tank shall open and discharge water into adjacent open-site drain when fluid pressure rises above 125 psig or when fluid temperature rises above 210 degrees F.

9. Calibrating Balancing Valves

   a. Calibrated balancing valves shall be suitable for 125 psig and 250 degrees F service. Calibrated balancing valves shall be of bronze body / brass ball construction with seat rings compatible with system fluid and shall have differential readout ports across valve seat area. Readout ports shall be fitted with internal insert of compatible material and check valve. Calibrated balancing valves shall have memory stop feature to allow valve to be closed for service and reopened to set point without disturbing balance position, and shall have calibrated nameplate to assure specific valve settings.

10. Air Vents

    a. Brass or bronze valves or cocks suitable for 125 psig service. Air vents shall be provided with threaded plugs or caps.

11. Strainers

    a. ASTM F 1199, removable basket and screen, Y pattern, cast iron strainer with pressures to 125 psig, simplex type; or a combination elbow-strainer with straightening vanes and strainer arranged for horizontal flow.

12. Pressure Gauges

    a. ASME B40.100. Pressure gauges shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inch.

13. Thermometers

a. ASME PTC 19.3, Type I, Class 3. Thermometers shall be supplied with wells and separable bronze sockets.

14. Pipe Threads

a. ASME B1.20.1.

15. Pipe Supports

a. MSS SP-58 and MSS SP-69. Metal insulation shield shall be stainless steel.

16. Aluminum Sheets

a. ASTM B 209M ASTM B 209, Alloy 3003.

17. Copper Sheets Copper Alloy 110

a. ASTM B 152/B 152M.

2.3 ELECTRICAL WORK

A. Electrical equipment and wiring shall be in accordance with Section 16120 "Conductors and Cables." Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.4 COLLECTOR SUBSYSTEM

A. Refer to Section 13610 “Heating, Flat-Plate, Solar Collectors” for collector array equipment information.

B. Piping

1. Array piping shall include interconnecting piping between solar collectors, and shall be connected in a reverse-return configuration as indicated with approximately equal pipe length for any possible flow path. Flow rate through the collector array shall be as indicated. Automatic pressure relief valves shall be provided in the array piping system, and shall be adjusted to open when the pressure within the solar array rises above 125 psig. Each collector bank shall be capable of being isolated by valves, and each bank capable of being separated shall have a pressure relief valve installed and shall be capable of being drained. Manually operated air vents shall be located at system high points, and all array piping shall be pitched a minimum of 0.25 inch/foot so that piping can be drained by gravity. Calibrated balancing valves shall be supplied at the outlet of each collector bank.

2.5 STORAGE TANK

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. RECO Industries.
2. Cemline.
3. Hubbel.

B. Solar system hot water storage tank shall have an actual storage volume as indicated on plans and schedules; the nominal volume listing is not acceptable. The tank shall be constructed under Sections VIII of the ASME Code. Manufacturer's Data Reports, Form U-1, shall be furnished.

C. The tank shall be cement lined storage vessel with nonferrous connections and a 10 year, non-pro-rated warranty on shell & lining (against tank leakage, rusty water, or lining failure). Tanks requiring sacrificial anodes are not acceptable. Tanks shall include ASME T & P relief valve, insulation with a minimum "R" Value of 12.8, covered with steel jacket, cold water inlet diffuser pipe, lifting lugs for handling, 12" x 16" ASME manway for lining inspection, nonferrous connections sizes as shown on drawings, and digital direct-reading temperature transducer with thermo well.

2.6 TRANSPORT SUBSYSTEM

A. Plate Heat Exchanger

1. A plate and frame heat exchanger shall be a single pass configuration with double-wall, type 316 stainless steel heat transfer plates, stainless steel connections, and a carbon steel carrying bar. Heat exchanger shall meet the capacities, heat transfer area, and characteristics as shown in the Equipment Schedule drawings. Plate ports shall be double- gasketed, of a one piece design formulated from Nitrile rubber. Plates shall be grooved to accept the gaskets and gasket clips to minimize movement. The heaters shall include OSHA approved splash guards. Unit shall be constructed in accordance with ASME Code Rules and shall have a manufacturer's data report for pressure vessels, form No. U-1.

2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Bell & Gossett GPX Series.
b. Tranter.
c. Alpha Laval.

B. Pumps

1. Refer to 15441 "Domestic Water Pumps".

2. Motors shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service and

for the heat transfer fluid used, and shall conform to the requirements specified in electrical sections.

3. Motors shall be controlled by suitable switches that can be activated by either the differential temperature controller or by manual override. Each pump suction and discharge connection shall be provided with a pressure gauge.

C. Pipe Insulation

1. Pipe insulation and coverings shall be the following, applied in accordance with Section 15088 “HVAC Piping Insulation”:

a. NPS 3/4 and Smaller:

Retain one or more of first three subparagraphs below.

1. Calcium Silicate: 3 inches thick.
2. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

b. NPS 1 and Larger:

Retain one or more of three subparagraphs below.

1. Calcium Silicate: 4 inches thick.

2. Mineral-Fiber, Preformed Pipe, Type I or II: 4 inches thick

2. Array piping insulation shall be capable of withstanding 250 degrees F, except that piping within 1.5 feet of collector connections shall be capable of withstanding 400 degrees F.

D. Drain-back Tank

1. Furnish and install Solarhot Model S-T-30SSDB drain-back tank with a minimum storage capacity of 30 gallons. The tank shall be constructed of 304 stainless steel and covered with 1” of foam insulation and a non-corroding, ABS plastic jacket. Lined tanks are not acceptable due to fluctuating water level and water temperatures.

2. The tank shall consist of the following components assembled in a complete factory package

a. Pressure relief valve.

b. Sight glass.

c. Dip tube for quiet operation.

3. The tank shall have a 5 year warranty.

E. Heat Transfer Fluid

1. Solar collector loop fluid shall be domestic potable water.

2.7 CONTROL AND INSTRUMENTATION SUBSYSTEM

A. Solar Control Subsystem

1. Differential Temperature Controller

a. Solar controller shall be a Stiebel Eltron Model SOM 7. The controller shall provide a clear operating concept and is equipped with illuminated combined display with system-monitoring. Flashing symbols for sensors, pumps and valves enable an immediate allocation of temperatures, temperature differences and active actuators. Controller shall have two programmable relay outputs for pump control, and high temperature functions. Controller shall monitor panel discharge temperature, panel supply temperature, and solar store temperature. In addition, the controller shall monitor pump run time and flow rate to calculate and totalize system heat transfer.

b. Automatic control equipment shall be installed at the location shown, in accordance with the manufacturer's instructions. Control wiring and sensor wiring shall be installed in conduit. Collector temperature sensor shall be mounted in a temperature sensor well in the fluid stream at the solar array outlet that is representative of the highest output temperature of the system. All control wiring shall be color coded and identified with permanent numeric or alphabetic codes.

B. Thermistor Temperature Sensors

1. Temperature sensors shall be 10-kOhm thermistors supplied by the differential temperature controller manufacturer, with an accuracy of plus or minus 1 percent at 77 degrees F. Model supplied must have passed an accelerated life test conducted by subjecting thermistor assemblies to a constant temperature of 400 degrees F or greater for a period of 1000 hours minimum. Accuracy shall have remained within plus or minus 1 percent as stated above. Thermistors shall be hermetically sealed glass type. Operating range shall be minus 40 to plus 400 degrees F. Immersion wells or watertight threaded fittings shall be provided for temperature sensors.

C. Sensor and Control Wiring

1. 18 AWG minimum twisted and shielded 2, 3, or 4 conductor to match analog function hardware. Control wiring shall have 600 volt insulation. Multi-conductor wire shall have an outer jacket of PVC.

D. Flow meters

1. Flow meters shall consist of a venturi, 6 inch dial differential pressure meter, valved pressure taps, and bar stock needle valves. Venturi flow nozzle shall have threaded bronze ends for pipe sizes up to 2 inches and flanged ends for pipe sizes 2-1/2 inches and above. Venturi length shall not be less than 1.6 times the pipe size. Venturi shall be selected to read differential pressure corresponding to 0.5 to 1.5 times the system flow

rate. Venturi shall have an accuracy of plus or minus 1 percent of the range. Meter shall have an accuracy of plus or minus 2 percent of the full scale range.

E. Sight Flow Indicators

1. Sight flow indicators shall consist of a clear glass window or cylinder and a nonferrous or 316 stainless steel body and impeller. Indicator shall have threaded ends for pipe sizes up to 2 inches and flanged ends for pipe sizes 2-1/2 inches and above. Maximum operating pressure shall be no less than 125 psig. Maximum operating temperature shall be no less than 250 degrees F.

2.8 PAINTING AND FINISHING

A. Equipment and component items, when fabricated from ferrous metal and located inside the building, shall be factory finished with the manufacturer's standard finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. After becoming thoroughly familiar with all details of the work, verify all dimensions in the field, and advise the Architect of any discrepancy before performing any work.

3.2 INSTALLATION

A. Collector Subsystem

1. Collector Array

a. Solar collector array shall be installed at the tilt angle, orientation, and elevation above roof as indicated. For installation on flat roofs with rack type collector mounting or for ground mounted collectors, bottom of collector shall be a minimum of 18 inches from roof or ground surface. For mounting on pitched roofs, back of collectors shall be installed a minimum of 2 inches above roof surface. Each solar collector shall be removable for maintenance, repair, or replacement. Solar collector array shall not impose additional loads on the structure beyond the loads scheduled on the structural drawings.

b. Refer to 13610 “Heating, Flat-Plate Solar Collectors” for additional requirements.

2. Array Piping

a. Collector array piping shall be installed in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. All piping must be coded with fluid type and flow direction labels in accordance with15076 “Identification for Plumbing Piping and Equipment” sections.

3. Array Support

a. Array support shall be installed in accordance with the recommendations of the collector manufacturer. Structural members requiring welding shall be welded in accordance with AWS D1.2/D1.2M for aluminum and welders should be qualified according to AWS B2.1/B2.1M.

4. Storage Subsystem

a. Solar storage tank penetrations shall be installed as shown so that cold water inlet to storage tank and outlet from storage tank to collector array is located near the bottom of the tank, and inlet from collector array and outlet to load are located near the top of the tank.

5. Transport Subsystem

a. Flow Rates
1) Flow rate in the collector loop shall be based on recommended collector flow rate, and shall be as indicated. Storage loop flow rate shall be at least 1.25 times the collector loop flow rate. All flow rates shall be below 5 feet/second.

b. Pumps
1) Base-mounted pumps shall be installed on foundations, leveled, grouted, and realigned before operation in accordance with manufacturer's instructions. Additional pipe supports shall be provided for close-coupled in-line pumps. All base mounted pumps shall have a straight pipe between the suction side of the pump and the first elbow. The length of this pipe shall be a minimum of five times the diameter of the pipe on the suction side of the pump, or a suction diffuser of the proper size shall be attached to the suction side of the pump.
2) In-line pumps shall have straight pipe between the suction side of the pump and the first elbow. The length of this pipe shall be a minimum of five times the diameter of the pipe size on the suction side of the pump.
3) Drain line sizes from pumps shall not be less than the drain trap or the pump dirt pocket, but in no case shall the drain line be less than 1/2 inch iron pipe size. Drain lines shall terminate to spill over the nearest floor or open sight drain.

c. Expansion Tank
1) Expansion tanks shall be installed on suction side of pump as shown.

d. Piping, Valves, and Accessories
1) Piping shall be installed in accordance with plumbing specification sections except where noted otherwise. Solders used on piping shall be as indicated. Piping shall be coded with fluid type and flow direction labels in accordance with 15076 “Identification for Plumbing Piping and Equipment”. Air vents shall be installed at the high points of the collector array and in the equipment room.

e. Pipe Expansion
1) Expansion of supply and return pipes shall be provided for by changes in the direction of the run of pipe or by expansion loops as indicated. Expansion

loops shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. Loops shall be cold-sprung and installed where indicated. Pipe guides shall be provided. Expansion joints shall not be used in system piping.

f. Valves
   1) Valves shall be installed at the locations indicated and where required for the proper functioning of the system. Valves shall be installed with their stems horizontal or above. Gate or ball valves shall be installed at the inlet and outlet of each bank of internally manifolded collectors. Calibrated balancing valves with integral pressure taps shall be installed at the outlet of each collector bank and at the pump discharge. Final setting for each valve shall be marked on each valve. Ball valves shall be installed with a union immediately adjacent. Gate valves shall be installed at the inlet and outlet of each pump and also at the inlet and outlet of each heat exchanger. A check valve shall be installed at pump discharges. Discharges of relief valves shall be piped to the nearest floor drain or as indicated on system drawings.

g. Foundations
   1) Concrete pads for storage tanks, heat exchangers, pumps, and other equipment covered by this specification shall be constructed in accordance with manufacturer's recommendations and be a minimum of 6 inches high with chamfered edges.

h. Grooved Mechanical Joints
   1) Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be the products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Grooved width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with the coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.3 SOLAR THERMAL SYSTEM CONTROLS

A. Solar Thermal System Monitoring

1. Provide a microprocessor based controller(s) for the automatic control of system. Provide all instrumentation, wiring, and field installation required for a complete and working system.
2. System shall provide status and performance monitoring data connection output for connection to a third-party Building Automation System (BAS).
3. Production Monitoring: Provide instrumentation required to measure the following parameters, to permit production monitoring, performance analysis, and alarming by BAS via a data connection output.

a. System solar production instantaneous BTUs.
b. System solar production daily total BTU-Hr.
c. Solar radiance.

4. System Status Monitoring: Provide instrumentation required to measure the following parameters, to permit system status monitoring and alarming by BAS via a data connection output.

a. Pump run status (each pump).
b. Valve position (each automatic control valve).
c. Collector inlet and outlet temperatures.
d. System water flow (for BTU meter).
e. Ambient outdoor temperature.
f. Solar storage tank internal temperature.
g. Solar storage tank outlet temperature.
h. Supplemental water heater(s) common outlet temperature.
i. Domestic hot water temperature (post-tempering valve).
j. All system alarms, faults, or warnings.

5. BAS Output: Provide one of the following output types for connection to a third-party BAS. Output may be provided integral to each device, or gateway may be provided to connect multiple devices physically located within the same room only.

a. Modbus/TCP protocol over Ethernet TCP/IP network. Provide full documentation of all available data points (address, type, scaling factors) and protocol parameters (device IP address, format).
b. Modbus/RTU protocol over EIA-485 network. Provide full documentation of all available data points (address, type, scaling factors) and protocol parameters (device address, baud rate, parity).

B. Control Subsystem

1. Differential Temperature Controller

a. Automatic control equipment shall be installed at the location shown in accordance with the manufacturer's instructions. Control wiring and sensor wiring shall be installed in conduit. Collector temperature sensor shall be mounted in a temperature sensor well in the fluid stream along the top manifold of a bank between two adjacent collector units. Unless otherwise indicated, operators, controllers, sensors, indicators, and like devices when installed on equipment casings and pipe lines shall be provided with stand-off mounting brackets, bases, nipples, adapters, or extended tubes to provide clearance, not less than the thickness of the insulation, between the surface and the device. These stand-off mounting items shall be integral with the devices or standard accessories of the controls manufacturer unless otherwise approved. Clamp-on devices or instruments where direct contact with pipe surface is required shall be exempted from the use of the above mounting items. All control wiring shall be color coded and identified with permanent numeric or alphabetic codes.

2. Sequence of Operation

a. The differential temperature controller sensing temperature difference between the fluid in a solar collector and water in the storage tank shall start solar collector loop and storage loop pumps when the temperature differential (Delta T - ON) rises above 15 degrees F, and shall stop the pumps when the differential (Delta T - OFF) falls below 5 degrees F. Programmable high limits shall activate 3-way diverting valves, transfer pumps or solenoid dump valves were shown on plans.

3.4 INSPECTION AND TESTING

A. Inspection

1. Make system available for inspection at all times.

B. Testing Prior to Concealment

1. Hydrostatic Test

a. All piping shall be tested at a pressure of 125 psig for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours, prior to installation of insulation. Expansion tank and relief valves shall be isolated from test pressure. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

C. Cleaning of Piping

1. System piping shall be flushed with clean, potable water prior to concealment of any individual section and prior to final operating tests. Prior to flushing piping, relief valves shall be isolated or removed. Solar collectors shall be covered to prevent heating of cleaning fluid, unless cleaning is performed during hours of darkness. The solution shall be circulated through the section to be cleaned at the design flow rate for a minimum of 2 hours.

D. Posting Framed Instructions

1. Framed instructions under glass or in laminated plastic shall be posted in the mechanical equipment room where solar heating equipment is contained. These instructions shall include a system schematic, and wiring and control diagrams showing the complete layout of the entire system. Condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above, and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted for approval prior to posting. The framed instructions shall be posted before acceptance testing of the system.

E. Acceptance Testing and Final Inspection

1. A written record of the results of all acceptance tests shall be maintained, to be submitted in booklet form. The tests shall be as follows:

a. As-Built Drawings
   1) Provide as a condition of final acceptance a complete set of as-built system drawings. Drawings shall clearly indicate the actual condition of the installed solar energy system at the time of the final test.

b. Final Hydrostatic Test
   1) Provide documentation indicating that all piping has been hydrostatically tested at a pressure of 125 psig for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours. Expansion tank and relief valves shall be isolated from test pressure. Gauges used in the test shall have been calibrated within the 6-month period preceding the test. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

c. System Flushing
   1) For final inspection, the system shall be thoroughly flushed, in no case for less than 2 hours, of all foreign matter until a white linen bag installed in a strainer basket shows no evidence of contamination. System shall be drained prior to final filling.

F. System Filling

1. System shall be filled through indicated connections with domestic potable water. Air shall be vented from the system after filling. System pressure at the high point on the roof shall be 10 psig minimum.

G. Operational Test

1. Operational test shall occur over a period of 48 consecutive hours with sufficient solar insolation to cause activation of the solar energy system during daylight hours. With system fully charged so that pressure at the high point on the roof or the lowest system pressure is a minimum of 10 psig and with fluid and pumps energized, flow meter must indicate flow as indicated. Calibrated balancing valves with pressure taps shall indicate bank flow rate as listed.

H. Control Logic

1. By substituting variable resistors for collector and storage tank temperature sensors, demonstrate the differential temperature controller correctly energizes the system pumps when the collector sensor indicates a temperature of 15 degrees F greater than the storage tank temperature, as indicated on the controller display panel. The differential temperature controller shall de-energize the system pumps when the displayed temperature of the solar collectors is 5 degrees F greater than the displayed temperature of the storage tank.

I. Temperature Sensor Diagnostics

1. Demonstrate that the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

J. Overall System Operations

1. Demonstrate that the solar energy system will operate properly while unattended for a period of at least 72 hours and that the controller will start pumps after being warmed by the sun, and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. Contractor is permitted to manipulate the temperature of the storage tank by the introduction of cold water at local groundwater temperature.

3.5 FIELD TRAINING

A. Provide a field training course for designated operating and maintenance staff members. Training shall be provided for a minimum period of 8 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. The training shall include discussion of the system design and layout and demonstrations of routine operation and maintenance procedures. This training shall include: normal system operation and control; flow balancing; detection of a nonfunctioning system due to sensor, controller, and/or mechanical failure; filling, draining, and venting of the collector array; replacement of sensors, collectors, and collector components; collector cleaning and inspection for leaks; and heat exchanger cleaning and expansion tank charging if applicable.

END OF SECTION 15486.1

SECTION 15766

CABINET UNIT HEATERS

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. All sections of Division 15 and 16 apply to this section.

1.2 SUMMARY

A. This Section includes cabinet unit heaters with centrifugal fans and hot-water, steam and electric-resistance heating coils.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

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. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Location and arrangement of integral controls.
4. Wiring Diagrams: Power, signal, and control wiring.

C. 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 cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
    a. Lighting fixtures.

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

6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For cabinet unit heaters to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for job site storage and protection of materials during construction.

1.7 EXTRA MATERIALS

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

1. Cabinet Unit Heater Filters: Furnish one spare filter.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Hot Water and Steam Units:
   a. Airtherm; a Mestek Company.
   b. Dunham-Bush, Inc.
   c. Engineered Air Ltd.
   d. International Environmental Corporation.
   e. Vulcan Radiator.
   f. Rittling

2. Electric Units:
   a. Chromalox, Inc.; a division of Emerson Electric Company.
   b. Indeeco.
   c. Marley Electric Heating; a division of Marley Engineered Products.
   d. Rittling.

2.2 CABINET UNIT HEATERS

A. Description: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

B. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.

1. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

C. Cabinet: Steel with factory prime coating, ready for field painting.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessing Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: Minimum 0.0528-inch thick steel, finished to match cabinet, 6 inches high with leveling bolts.

D. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated: 90 percent arrestance and 7 MERV.

E. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide. Insulating refractory; and sealed in a high-mass steel or corrosion-resistant metallic sheath with fins a minimum of 0.16 inch apart. Provide fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel

hardware. Fin surface temperature shall not exceed 550 deg. F at any point during normal operation.

F. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width centrifugal; directly connected to motor. Provide thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 15 Section "Motors."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

G. Control devices and operational sequences are specified in Division 15 Sections "HVAC Building Automation System" and "Sequence of Operation."

H. Basic Unit Controls:

1. Control voltage transformer.
2. Timer switch.
3. Safety-switch disconnect on cover of terminal box.
4. Mercury contactors.
5. Fan-delay relay.
6. Aquastat with adjustable setpoint interlocked with fan.
7. Unit-mounted thermostat with the following features.
   a. Heat-off switch.
   b. Fan on-auto switch.
   c. Adjustable deadband.
   d. Exposed set point.
   e. Exposed indication.
   f. Deg F indication.

I. Electrical Connection: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

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

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Install new filters in each unit within two weeks of Substantial Completion.

E. Install separate thermostats 5’ above finished floor.

3.3 CONNECTIONS

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

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

3.4 CLEANING

A. After construction and painting are completed, clean all exposed surfaces and vacuum interiors.

B. Retouch marred or scratched surfaces of cabinets. If units have factory-finished cabinets, use materials furnished by the manufacturer.

3.5 CONTRACTOR STARTUP AND REPORTING

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 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.

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

3.6 DEMONSTRATION AND COMMISSIONING

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

END OF SECTION 15766

SECTION 15767

PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. All sections of Division 15 and 16 apply to this section.

1.2 SUMMARY

A. This Section includes propeller unit heaters with hot-water and electric-resistance coils.

1.3 DEFINITIONS – NOT APPLICABLE

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each unit type and configuration.

B. Shop Drawings: Submit the following for each unit type and configuration:

1. Plans, elevations, sections, and details.
2. Details of anchorages and attachments to structure and to supported equipment.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE HANDLING

1.7 WARRANTY

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Hot Water Unit Heaters:
   a. Airtherm; a Mestek Company.
   b. Dunham-Bush, Inc.
   c. Modine Manufacturing Co.
   d. Sterling Radiator
   e. Vulcan.

2. Electric Unit Heaters:
   a. Marley Electric Heating Company, Berko Div.
   b. Indeeco.

2.2 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

B. Comply with UL 2021.

2.3 CASING

A. Cabinet: Removable panels for maintenance access to controls.

B. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 ELECTRIC-RESISTANCE HEATING ELEMENTS

A. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.5 FAN

A. Propeller type, aluminum wheel directly mounted on motor shaft in the fan venturi.

2.6 FAN MOTORS

A. Comply with requirements in Division 15 Section "Motors."

2.7 CONTROLS

A. Control Devices:

1. Unit-mounted thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

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

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

3.2 INSTALLATION

A. Install propeller unit heaters level and plumb.

B. Install propeller unit heaters to comply with NFPA 90A.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Division 15 Section "Hangers and Supports." Vibration hangers are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

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

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

3.4 CLEANING – NOT APPLICABLE

3.5 CONTRACTOR STARTUP AND REPORTING

A. Testing: Perform the following field quality-control testing and report results in writing:

1. 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 safeties.

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

3.6 DEMONSTRATION AND COMMISSIONING

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

END OF SECTION 15767

SECTION 15781

CUSTOM BUILT ROOF TOP UNITS (CBRTU)

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. All sections of Divisions 15 and 16 apply to this section.

1.2 SUMMARY

A. This Section includes custom build roof top units with the following components and accessories:
1. Cabinet and Frame.
2. Air-Cooled Condensing Section.
3. Compressors.
4. Evaporator Coil.
5. Gas Heater.
6. Supply Fans
7. Supply Fan Motors.
8. Filter Section.
9. Outside Air/Return Air/Exhaust Air Dampers.
10. Outside Air Louvers.
11. Power Return/Exhaust Fans.
12. Return/Exhaust Fan Motors.
13. Access Doors.
14. Main Control Panel.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. CBRTU: As used in this Section, this abbreviation means custom build roof top units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

C. Supply Air: The air entering a space from air-conditioning, heating, or ventilating apparatus.

D. Supply-Air Fan: The fan providing supply air to conditioned space.

E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each CBRTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories. Including but not limited to the following data:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound power ratings at system operating conditions.
   3. Certified ARI heating and cooling coil capacity ratings.
   4. Motor ratings and electrical characteristics of motor and fan accessories.
   5. Materials gauges and finishes.
   6. Filters with performance characteristics.
   7. Dampers, including housings, linkages, and operators.
   8. Supply fan, return fan, and compressor vibration isolation including vibration analysis.
   9. Material Safety Data Sheets.
   10. Installation and maintenance manuals containing all system components.
   11. Laboratory data for sound testing of fans.
   12. Performance at ARI standard conditions and at conditions scheduled (provide EER & IPLV).
   13. ASHRAE/IESNA 90.1 for energy compliance statement.

B. LEED Submittals:
   1. Prerequisite EA2: Provide certification that the minimum efficiency is equal to the requirements of the latest ASHRAE standard. Include performance at ARI standard/unloading conditions, and at conditions scheduled (provide EER).
   2. Credit EA1: Provide certification that the minimum efficiency betters the requirements of the latest ASHRAE standard. Include performance at ARI standard/unloading conditions and at conditions scheduled (provide EER).
   3. Credit EA4: Certification that refrigerants are free of HCFCs.
   4. Credit EA5: Product Data of continuous metering equipment for outdoor airflow and energy consumption.
   5. Credit EQ5: Certification that equipment has been provided with MERV 13 filters.

C. Shop Drawings: Detail equipment assemblies, including control panel, and indicate dimensions, weights, loads, required clearances, method of field assembly, components, location and size of each field connection and rigging and hoisting requirements.
   1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.
   2. Provide as part of the shop drawing details a complete compressor and condenser cross section.

D. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Components of multi-zone CBRTUs.
   2. Structural members to which CBRTUs are to be attached.
   3. Roof openings.
   4. Roof curbs and flashing.

E. Factory quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For CBRTUs to incorporate in emergency, operation, and maintenance manuals. Include all unit components including but not limited to dampers, fans, motors, filters, belts, and controls.

H. Startup Test Reports: Submit written test reports documenting the activities required by Part 3 "Contractor Startup and Reporting". These reports are to be submitted two weeks after the startup is completed.

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

1.5 QUALITY ASSURANCE

A. AMCA Compliance:
1. Comply with AMCA 300 and 301 for testing and rating airborne sound emissions of fans. Submit laboratory test data.
2. Comply with AMCA 500 for testing and rating of dampers and louvers.
3. Comply with AMCA 204 for testing and rating balance quality and vibration levels for fans.

B. ARI Compliance:
1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for CBRTUs.
2. Comply with ARI 270 for testing and rating sound performance for CBRTUs.
3. Comply with ARI 430 for testing and rating equipment performance for CBRTU's.
4. Comply with ARI 410 for testing and rating coil capacities.
5. CBRTU's to be certified in accordance with ARI Certification Program.

C. ASHRAE Compliance:
1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 52.1 for filter efficiency.
3. Comply with ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.

D. NFPA Compliance: Comply with NFPA 90A, NFPA 90B and NFPA 79.

E. 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. Unit shall comply with Chicago Electrical & Refrigeration Codes and applicable NEMA standards.

F. Safety Standards:
1. Design, manufacture and installation of mechanical refrigeration equipment: ANSI B9.1
2. Machinery Guards: Provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings. Comply with the latest OSHA standard.
3. Comply with City of Chicago Building Codes.
4. Comply with Chicago Fire Code requirement for smoke detection in supply air to shut down unit and notify unit status.

G. Corrosion Prevention: Unless specified otherwise, equipment fabricated from ferrous metals that do not have a zinc-coating conforming to ASTM A386 or a duplex coating of zinc and paint shall be treated for prevention of rust with a factory coating or paint system that shall withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall be tested for 500 hours. The salt-spray fog test shall be in accordance with ASTM B117 using a 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no signs of blistering, wrinkling or cracking, no loss of adhesion, and the specimen shall show no signs of rust creepage beyond 1/8 inch on either side of the scratch mark. The film thickness of the factory coating or paint system applied on the equipment shall be not less than film thickness used on the test specimen.

H. Factory Leak Testing:
1. The manufacturer is to provide a factory leak test on the units for 6 inch W.C. positive pressure and 2 inch W.C. negative pressure inches of water differential static pressure across the exterior cabinet walls.
2. Cabinet leakage not to exceed 1% of the specified airflow for the unit over a twenty (20) minute period.
3. Seal all panels with closed cell gasket material.
4. Submit a written certified leak test report for Owner approval/signoff prior to shipment.

1.6 DELIVERY, STORAGE AND HANDLING

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

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

1.7 COORDINATION

A. Verify dimensions of existing roof curbs and duct connections.

B. Coordinate existing roof top unit removal and CBRTU installation schedules with Owner.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan Belts: One set for each belt-driven fan.
2. Filters: Two sets of filters for each unit.

1.9 WARRANTY

1. Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of CBRTUs that fail in materials or workmanship within specified warranty period. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion whichever is longer.

2. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of substantial completion. Warranty shall be on compressor exchange. Parts only warranty is not acceptable.
3. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than eleven years from date of Substantial Completion.
4. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
5. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Mammoth Inc.
   2. Seasons-4, Inc.

2.2 GENERAL DESCRIPTION

A. Furnish and install rooftop unit of size, type and capacity as indicated on the Drawings. Cooling capacity ratings shall be based upon test in accordance with ARI Standard 360. Units shall consist of insulated weather tight casing, compressors, air-cooled condenser coil, condenser fans, condensate drain pan, evaporator fan, gas fired heater, return/exhaust fans, motors and drives, and main control panel. Unit shall be custom built to match existing roof curb, zone duct header, return opening, gas piping connection location, etc. Units that require modification to existing curb or ducts are not acceptable unless expressly stated so in design documents. Units shall also include filters, return/exhaust fans and controls as herein specified.
   1. Units shall include blow-through multi deck section with gas heat and DX cooling in cold deck, supply fan section, return fan section, condensing unit section, filter section and control dampers for outside air, exhaust air and return air.
   2. Capacities, characteristics, and accessories shall be as shown and/or scheduled on drawings.
   3. Units shall be factory fabricated, assembled and factory finished.
   4. Motors shall not be installed above any fans.
   5. Max. operating weight shall not exceed equipment schedule weights shown on the design drawings including roof curb, if provided. Provide certified weights with submittals.
   6. Units shall include heating section and controls. Heating shall be natural gas.

B. Units shall bear UL, CSA or ETL labels.

2.3 CAPACITIES AND CHARACTERISTICS:

A. Efficiency:
   1. Air conditioners shall have a EER and IPLV better than ASHRAE Standard 90.1 – latest edition under ARI test procedures. When air conditioners with higher efficiencies then

the Standard are scheduled on the drawings, the more efficient value shall be the minimum project requirement.

2.4 CABINET AND FRAME

A. The unit framework shall be welded structural tubing or integrally formed steel around perimeter or 12 gauge formed galvanized metal with integral curb flashing, electrically welded and painted with primer and one finish coat of paint for maximum protection from rust. Decks shall be double wall construction fabricated from minimum 18 gauge, galvanized steel. perforated. Entire top panel and deck under the filter section shall have inner liners fabricated from 22 gauge galvanized steel either solid or perforated.

B. Formed outer panels shall be secured to a welded tubular steel frame. Casings, panels, frame channels, and floors shall be constructed to withstand specified operating pressures including safety factors.

C. The roof of the unit shall be pitched to provide positive drainage. Top seams shall be covered with cap strips to prevent water leakage into the unit. All seams shall be sealed to prevent air and water leakage.

D. All exterior panels shall be insulated 2 inches double wall fabricated from 18 gauge galvanized steel or aluminum of equivalent strength.

E. Ceiling, walls, deck and doors shall be double wall as specified above with minimum 2 inches of R-8 insulation. No exposed insulation shall be permitted. Single wall or un-insulated doors shall not be acceptable.

F. Lifting lugs shall be provided on the base of the unit for rigging and shall accept cable or chain hooks.

G. Each panel shall be water and moisture tight to prevent water damage, electrical hazard and mold contamination within the unit.

H. The following requirements apply to individual components:
   1. Base Frame:
      a. Provide a full perimeter welded base frame constructed of minimum 12 gauge rectangular structural steel tubing or formed and welded structural members with integral curb flashing and minimum 14 gauge structural steel cross members. Formed metal base rails bolted or screwed together are not acceptable.
      b. Cross members shall be welded to the perimeter frame at a minimum of one member per every two feet.
      c. Base frame shall be painted with industrial direct to metal (DTM) finish with built-in rust inhibitors.
      d. Base frame shall be attached to unit at factory.
   2. Wall and Roof Frame:
      a. Wall and roof frame are to be minimum 14 gauge rectangular structural steel tubing welded to form a unitized assembly for support of all internal components. Formed, screwed, and bolted metal is not acceptable.
      b. The frame is to be coated with corrosion resistant phenolic primer.
   3. Floor:

a. R-8 insulation "double bottom" floor with minimum 16 gauge G-90 galvanized outer surface and minimum 16 gauge G-90 galvanized inner walk-on surface is to be provided.
b. All floor seams are to be sealed airtight.
c. Single walled floors with glued and pinned insulation are not acceptable.

4. Casing /Panels:
   a. 2 inches double wall construction fabricated from 18 gauge galvanized steel or 18 gauge (.04 inches) prepainted aluminum with baked acrylic enamel exterior and 22 gauge galvanized steel or aluminum of equivalent strength interior panels with R-8 insulation.
   b. Flat panel design is not acceptable.
   c. Panels shall not to exceed 24 inches without a structural steel support member in one axis.
   d. Casing structure shall use insulating thermal breaks so that there is no path of continuous metal-to-metal conduction from inner to outer spaces.
   e. Panels shall be gasketed and secured to tubular steel or formed frame with zinc plated fasteners and neoprene washers. Fasteners shall be of design using double locknuts/locktite. Aluminum panels shall be isolated from steel frame with dielectric gaskets to prevent galvanic corrosion.
   f. Roof and internal components shall be supported from a structural frame, rather than side panels.
   g. All panels shall be sealed airtight.
   h. All sections shall be independent to preclude airflow between sections except airflows within the unit.
   i. Install gutter over the access doors and electrical panels.

2.5 AIR COOLED CONDENSING SECTION

A. Two condenser fans minimum shall be coated steel and have a steel hub locked on a 316 stainless steel motor shaft. Fans shall be direct drive 3 phase RPM NEMA compliant motors.

B. Condenser coils shall be a seamless copper tubes, expanded into aluminum fins with a maximum of ten fins per inch. Each coil shall be provided with 15 degrees F sub cooling circuit. The mechanical refrigeration system shall be capable of operating at ambient conditions down to 45 degrees F.

C. Provide easily removable hail guards over condenser surface.

D. The unit manufacturer shall manufacture the condensing section. Third party condensing sections bolted to the unit are not acceptable.

E. Condenser section floor shall be crowned for water drainage and constructed of 16 gauge. stainless steel or aluminum of equivalent strength to resist corrosion.

F. All refrigerant piping shall be Type K Copper and installed and factory pressure tested prior to shipment of the unit.

G. Condenser fan motors shall have a shaft slinger to prevent liquid/ moisture from seeping into the motor.

2.6 COMPRESSORS

A. Unit shall have a minimum of two compressors. Compressors shall be heavy duty suction cooled, hermetic scroll type, complete with forced feed lubrication, suction and discharge service valves, suction strainer, crankcase heater, and 3 phase solid state thermal motor protection. The compressors must be mounted on rubber in-shear isolators to prevent transmission of any noise and vibration to the space below. One of the compressors shall have hot gas bypass.

B. Each compressor shall have an independent refrigeration circuit completely piped, tested, dehydrated, and fully charged with oil and refrigerant R-134A or R-410A. The refrigerant circuit components shall include compressor, condenser with integral liquid sub cooler, liquid line service charging valve, removable core filter drier, sight glass and relief valve. Suction piping shall be insulated.

C. Capacity reduction shall include hot gas bypass.

D. Compressors shall be mechanically air cooled, and shall be located so as to not allow leaking refrigerant to enter the airflow into occupied space.

E. Compressors shall not be located in the same compartment as electrical contactors and control panels.

F. Compressors shall be interlocked with gas heat so that compressors shall be locked out when gas heating is enabled.

G. Refrigerant Systems shall be provided with relief valve capability in compliance with the Chicago Building Code.

H. Controls shall include compressor anti-short cycle timers.

I. Provide Low and high-pressure refrigerant safety shut offs.

2.7 EVAPORATOR COIL

A. Direct expansion coil shall be staggered ½ inch O.D. x 0.029 inch wall seamless copper tubes expanded into aluminum fins and shall not be less than three rows in depth, nor have more than twelve fins per inch. Coil casings shall be constructed of heavy gauge galvanized steel. Headers shall be copper. Evaporator coils shall be provided with thermostatic expansion valves, adjustable superheat controls, and external equalizers. Expansion devices to be located out of airstream. Coil capacities and pressure drops are rated in accordance with ARI Standard 410.

B. The evaporator coil drain pan shall be 22 gauge 316 stainless steel and coil shall be provided with vibration dampening stiffeners, thermal insulation and discharge pipe. This applies to each coil. Where coils are stacked, unit shall be equipped with intermediate drain pan and internal drain pipes to the lowest pan.

C. Provide a condensate drain connection on both sides of the unit fitted to allow field piping to nearest roof drain.

2.8 GAS HEATER

A. The heater shall be a natural gas indirect fired type with capacity as scheduled and shall be installed downstream of the supply fan in the heating deck of the unit. The heat exchanger primary drum and secondary tubes shall be constructed of formed and welded series 409 or 304 stainless steel. The burner shall be of the power firing type and shall incorporate a primary combustion air blower and spark ignition transformer. The gas train shall be complete with all controls factory mounted to comply with requirements of CSD-1 and AGA. Shut-off valve shall be located outside of the unit casing, upstream of the pressure regulator. Standard controls shall include a modulating main gas valve, flame supervision, positive burner safety switch, pilot gas cock, main gas cock, and adjustable main and pilot pressure regulators. Main gas shall be outside unit casing. The gas train shall be ready for connection to a natural gas supply with pressure between 4 inches and 14 inches WC. The complete unit shall be test fired and preliminary adjustments made prior to leaving the factory. Final adjustments shall be made in the field during unit start-up. See Part 3 for manufacturer's field services. Unit shall include multiple stages with low fire until a temperature is satisfied to keep the heat exchange from overheating.

B. Provide modulating gas valve with turn down ratio of 7:1 for units less than 400,000 BTUH, 10:1 for all others.

C. Provide a safety disconnect switch in the exterior mounted control panel for the furnace. Switch shall be protected from accidental contact, such as ice sliding down the exterior, with a collar.

D. Furnace control shall be such that MANUAL restart shall be required after one (1) attempted AUTOMATIC restart.

E. Flue gas discharge shall be extended a minimum of 72 inches above the top of the unit with a double walled 18 gauge 316 stainless steel stack as shown on the drawings. Stacks shall be supported without cables to withstand winds defined in the Chicago Code. This extension shall not adversely effect the operation of the burner. The exhaust flue from the heater exchanger to the outside shall be 316 stainless steel.

2.9 SUPPLY FANS

A. The fan shall be a single or double width centrifugal airfoil plenum fan, secured to a machined, ground and polished steel shaft. The shaft shall be coated with rust inhibitor and shall be supported with two outboard bearings. Bearings shall be of the self-aligning, ball bearing pillow block type, and shall be designed for a minimum L-50 (200,000 hours) average life at the maximum horsepower and operating speed for the classification. Drive shall be by means of multiple V-belts with a minimum service factor of 150 percent. Belts shall have belt tension adjustment provided. Final belt tension adjustments shall be made after unit installation. Forward curved fan blades are not acceptable.

B. Bolts, screws, set screws nuts and fasteners shall be of design using double locknuts/locktite.

C. Fans shall be designed for continuous operation at the maximum rated fan speed and motor horsepower.

D. Fans shall be statically and dynamically balanced per ISO Standard G6.3 in the fan housing after the final assembly. Motor balance shall also be checked.

E. Factory and motor balance shall be measured at bearing locations in three directions. Measurements shall include peak velocity (inches/second) and shall not exceed the maximum value of 0.2 in./sec. After field test, adjust, balance (TAB), contractor shall verify the units remain within vibration specification.

F. Motor pulleys shall be adjustable pitch for motors through 5 hp, and fixed pitch for motors larger than 5 hp. Adjustable pulleys shall be selected so that pitch adjustment is in the middle of the adjustment range at fan design conditions.

G. Provide OSHA belt guards in service corridors or where exposed with perforated facing and tachometer openings for motor and fan shaft rpm measurements.

H. Provide grease lubricated fan bearings with grouped accessible fittings, located within one foot of a door for lubrication. Both bearings shall have the same bore, type and manufacturer.

I. Fan housing shall be heavy gauge, continuously welded, structural steel construction. Formed or bolted steel construction is not acceptable.

J. Fan wheel and sheaves shall be keyed to the shaft.

K. Fan blades shall be hollow airfoil type, welded to the center and wheel side plates.

L. Mount fans on rubber-in-shear isolators to prevent transmission of any noise and vibration ot the space below. Formed metal isolation bases are not acceptable.

M. Fan and motor combination inertia base shall be welded steel. Total weight of the fan and motor inertia base shall, at a minimum, be equal to the fan and motor weight.

N. Provide flexible connection between fan discharge and ductwork to the next section. Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

O. Units shall be horizontally restrained to structural member to limit horizontal motion during startup.

2.10 SUPPLY FAN MOTOR

A. The fan motor shall be heavy duty TEFC, three phase, 1800 rpm, NEMA Premium (per the latest NEMA standard). The motor and fan shall be mounted on the common isolated steel frame assembly.

B. Motors shall be selected so that they do not operate within the 1.15 service factor at total fan pressures +/-10% from design selection point.

C. Provide adjustable motor base that can be adjusted with jackscrews.

2.11 FILTER SECTION

A. Provide access doors at both sides of the unit for easy filter changing.

B. Provide racks for 2 inches pre-filters. Filter mounting systems shall be factory assembled, side access, consisting of a housing, access doors, and filter tracks. Filter housing shall be 16 gauge galvanized steel. Tracks shall be constructed of aluminum of equivalent strength for corrosion prevention. Mounting of filters in these tracks shall prevent air bypass. Blank-off panels shall be provided for systems with filter sizes that do not match housing.

C. At rated airflow, the leakage out of the assembly shall not exceed 1% at 3 inches w.g. positive pressure and leakage into the assembly shall not exceed 0.5 inch at 3 inches w.g. negative pressure.

D. The effective filter media shall not be less than 4.6sq.ft. of media per 1 sq.ft. of filter face area and shall contain not less that 15 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.2815 inch w.c.. Filters shall be sized at a maximum of 500 fpm velocity and shall be MERV 13 filters.

E. The filter media support frame shall be constructed of rigid, heavy duty, high wet strength board with diagonal support members bonded to the filter media to eliminate the possibility of media oscillation and media pull away.

F. Filter section shall be designed to allow airflow through the media without blockage by the supply fan, return fan or outside dampers due to proximity to the filters. A perforated metal plate with a net free area 50% greater than the return/outside air damper shall be installed in front of the filters to prevent jet air damaging the filters. The air flow velocity through the filters shall be less than 500 fpm.

G. Provide differentiated pressure transmitter across the filter section. Interface with CBRTU control panel ready for tie-in to the building automation system.

2.12 OUTSIDE AIR/RETURN AIR/EXHAUST AIR DAMPERS

A. Damper frames shall be u-shaped 14 gauge galvanized metal sections securely screwed or welded to the air handling unit chassis. Damper area between frames shall be a maximum 16 square feet. Full damper width pivot rods of 1/2 inch galvanized steel shall turn in oil impregnated bronze bushings. Rods shall be secured to the blade by means of straps and set screws.

B. Return damper blades shall be 18 gauge galvanized metal with two racks on each edge and three breaks on centerline for rigidity. The pivot rod shall "nest" in the centerline break. Damper edges shall interlock. Maximum length of damper between supports shall be 36 inches. Damper linkage brackets shall be constructed of galvanized metal. Outside air and exhaust damper blades shall be heavy gauge aluminum, air foil type.

C. Outdoor and return air damper frames shall be 12 gauge extruded aluminum mechanically fastened to the air handling section. Pivot rods shall be ½ inch diameter extruded aluminum shafts that securely lock the aluminum airfoil damper blade to the staff. Axle bearings shall be celcon polycarbonate or equivalent. The seals and blades shall both overlap to assure minimum

leakage. The silicon seal shall fit in an extruded groove in the blade and the side seals shall be stainless steel, spring steel seals at the jamb.

D. Return air dampers shall be standard construction opposed blade type and shall include blade ends interlocked and sealed with an adhesive backed foamed polyurethane gaskets to minimize leakage.

E. Outdoor air intake and exhaust dampers shall be parallel blade type and also include an all weather PVC seal, fastened with a positive lock grip and pliable overlap edge on entering air side of interlocking edges. Damper blade operators are fastened at the blade center.

F. Leakage rate of outside air and exhaust air dampers shall not exceed 3 cfm/sq.ft. at 3 in. wg.

G. All dampers (outside air/return air/exhaust air) shall be motorized. Damper motors/operators shall be provided and installed by unit manufacturer. Refer to Division 15 Building Automation System for actuator requirements.

2.13 OUTSIDE AIR LOUVERS

A. Outside air louvers shall be of a storm proof design and provided with a ½ inch x ½ inch galvanized bird screen. A fully insulated divider deck shall be provided to separate outside air from return air.

B. Outside air louvers and ductwork shall be sized for 100% unit supply air economizer cycle requirements. Velocity shall not exceed 500 FPM over the net free area.

2.14 POWER RETURN/EXHAUST FANS

A. The fan wheel shall be a single or double width/single or double inlet centrifugal airfoil plenum fan or double width/double inlet forward curved type as scheduled on plans, secured to a machined, ground and polished, solid steel shaft. The shaft shall be coated with a rust inhibitor and supported by two outboard bearings. Bearings shall be of a self-aligning, ball bearing pillow block type and shall be designed for a minimum 200,000 hours average life. Drive shall be provided with a pair of multiple V-belts with a minimum service factory of 150 percent. Final belt tension adjustment shall be made after unit installation.

B. Bolts, screws, nuts and fasteners shall be of design using double locknuts / locktite.

C. Return fan shall be designed for continuous operation at the maximum rated fan speed and motor horsepower providing 100% of supply air unless otherwise shown in equipment schedules.

D. Provide flexible connection between fan discharge and ductwork to the next section. Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

E. Mount fans on rubber-in-shear isolators to prevent transmission of any noise and vibration to the space below. Formed metal isolation bases are not acceptable.

2.15 RETURN/EXHAUST FAN MOTORS

A. The fan motor shall be heavy-duty TEFC, three phase, 1140 rpm, NEMA Premium. The motor and fan shall be mounted on a common isolated steel frame assembly.

B. Motors shall be selected so that they do not operate within the 1.15 service factor at total fan pressures +/-10% from design selection point.

C. Provide adjustable motor base that can be adjusted with jackscrews.

2.16 ACCESS DOORS

A. Access doors shall be a minimum of 18 gauge steel double wall construction with R-8 insulation between inner and outer wall.

B. Access doors shall have handles inside and outside of unit.

C. Access door frame shall be welded structural steel with low-leakage air-bulb type seal. Seal shall be secured to the frame with rivets or weatherproof mastic or sealant.

D. Hinges shall be stainless steel, continuous (piano-type), heavy duty, 10 gauge galvanized steel, and shall be riveted to the access door and frame.

E. Doors shall open against pressure.

F. Provide hinged access doors on both sides of unit for fan, filter, control damper, and coil section. Also, provide doors for furnace and compressor access.

G. Access doors shall have locking type door retainer to prevent wind damage when door is open. Top and bottom retainers shall be installed for large doors to prevent racking.

H. Access door to be minimum 60 inches or full height minus 4 inches for units less than 60 inches tall.

I. Provide high compression single handle multiple closure type hatches/handles for quick access and positive air seal.

J. Access doors shall be equipped with gutters extending 3 inches on either side of the door opening.

2.17 MAIN CONTROL PANEL

A. The main operating and control panel enclosure shall be a minimum 8 inches deep and equivalent to NEMA type 3R (rain-tight) and Chicago Electrical Code compliant. The panel front shall be piano hinged at the top or have two outward swinging doors, key lockable at the

bottom and have hold open devices for protection and safe maintenance in all weather conditions.

B. Panel shall have an insulated divider between power and control sections. Each section shall have terminal strips numbered to match wiring diagrams that identify field wiring and factory wiring. The control panel shall be structurally isolated from the unit curb so that conduits do not penetrate the curb.

C. The main panel shall accommodate an external electric service feeder consisting of four copper wires in a 3 inches IMC conduit to energize the unit.

D. Adjacent to the control panel provide a quad GFI outlet for unit maintenance on the unit exterior and capable of receiving a ¾ inch IMC conduit and wiring. This is to provide maintenance capability with the control panel main switch de-energized.

E. Provide unit interior lighting which is to be switched on the interior wall of the main access door. The circuit shall be extended through the exterior panel and terminated in a NEMA 3R junction box to allow others to field connect a separate lighting circuit to allow maintenance with unit main power switched off.

F. Panel access doors shall be equipped with gutters extending 3 inches beyond sides of the door opening.

G. High voltage wiring shall be separated from low voltage wiring on the same panel.

H. Any external mounted disconnect switch shall be installed in a weather protected enclosure.

2.18 DDC TEMPERATURE CONTROL SYSTEM

A. General Description

1. Each unit shall be furnished complete with all operational controls. These controls include the hardware and software required to operate the Custom Build Roof Top Unit (CBRTU) according to the sequence of operations specified in other Division 15 specification sections and as shown on the drawings. Each of the CBRTU local DDC controllers shall be integrated into the schools temperature control system specified in other Division 15 specification sections. The equipment manufacturer is responsible for all wiring in the CBRTU.
2. The controls contractor shall supply the local controller for the CBRTU. The CBRTU manufacturer shall factory install the controller in each CBRTU.
3. All input, output and DDC local devices are to be factory installed and wired, except the room thermostat/sensor, and supplied to the CBRTU manufacturer by the contractor supplying the local controller. All the devices in the CBRTU shall comply with the requirements of the temperature control specification in Division 15. Room temperature sensors shall be furnished and installed by the control contractor connected to the local controller at the CBRTU.
4. See drawings and Division 15 for control diagrams, points list and sequence of operation.
5. Factory-mounted and wired controls also include system on/off switches, lights and safety controls.

B. DDC panel shall be protected from voltage transients and lightning strikes with AC voltage clamping at 140 Volts RMS (330 V UL 1449) and network grade surge suppression rated at 2350 joules

C. The above components are in addition to electrical components associated with other sections, which shall be incorporated in the main control panel to facilitate maintenance and troubleshooting.

2.19 TESTS AND SHIPMENT

A. The complete system including sensors (refrigerant, heating, air handling and controls) shall be factory run-tested as a component as well as part of the total unit prior to leaving the factory.

B. Each unit shall ship from the factory fully charged, in one piece with all options factory installed and factory run-tested as a complete unit.

2.20 ADDITIONAL ITEMS

A. Provide GFI service outlets with separate transformers so that circuit is energized even when main disconnect is off.

B. Provide marine type lights in control and fan sections.

C. All motors and electric devices shall be separately fused for over-current protection to minimize total unit out of service conditions. Fuses shall be integral to the unit.

D. Internal wiring for all electrical devices/controls shall be properly sized for ampacity and to match connections without damaging/stripping the conductor.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

A. Remove existing rooftop unit(s) in their entirety. Temporarily protect existing curb with weatherproof cover until new unit is installed.

B. Refer to the drawings for replacement curb details and dimensions.

C. New unit shall sit neatly and level on the curb. Notify Authorized Commission Representative if any defects are observed in an existing curb or ducting inside the curb that would prevent a proper installation. Blank-offs, filler pieces, shims and other similar field-installed accessories used to make new unit fit existing curb and ducting are not acceptable.

3.2 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation, tolerances and other conditions affecting performance of CBRTUs.

B. Examine roughing-in for CBRTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roof condition before CBRTUs are installed. Document any defects and deficiencies.

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

3.3 CONNECTIONS

A. Handle and install units and accessories in accordance with the manufacturer's printed instructions for the model.

B. Provide "P" trap at condensate drain sized to allow for units pressure and pipe over to nearest roof drain receptor.

C. Install piping adjacent to CBRTUs to allow service and maintenance.
   1. Gas Piping: Comply with applicable requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

D. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to CBRTUs with flexible duct connectors specified in Division 15 Section "Duct Accessories". Make new connections to each individual zone duct with flexible ductwork connection.
   4. Install return-air duct continuously through roof structure.

3.4 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face; comb coil fins.

C. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.5 CONTRACTOR STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to observe unloading and placement of unit and inspect, test, and adjust components, assemblies, equipment installations, and connections including piping, ductwork and electrical connections. Report results in writing with recommendations for corrective action.

B. Perform tests and inspections and prepare test reports. All testing and inspection requirements identified in this document or required as part of the manufacturer’s startup shall be documented in writing.

C. Final Checks Before Start-Up: Perform the following operations and checks before start-up; document in writing.
   1. Verify that shipping bolts, blocking, tie-down straps and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.
   3. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
   4. Perform cleaning and adjusting.
   5. Disconnect fan drive from motor, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
   6. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
   7. Set outside-air and return-air mixing dampers to minimum outside-air setting.
   8. Comb coil fins for parallel orientation.
   9. Install clean filters.
   10. Verify manual and automatic volume controls, and fire dampers in connected ductwork systems are in the full-open position.
   11. Disable automatic temperature control operators.

D. Tests and Inspections:
   1. After installing CBRTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
      a. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
      b. Replace fan and motor pulleys as required to achieve design conditions.
      c. Measure and record motor electrical values for voltage and amperage
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Shut unit down and reconnect automatic temperature control operators.

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

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for Procedures for air-handling-system testing, adjusting, and balancing

G. Engage a factory-authorized service representative to perform startup service.

H. Complete installation and startup checks according to manufacturer's written instructions and do the following:
   1. Inspect for visible damage to unit casing.
   2. Inspect for visible damage to furnace combustion chamber.
   3. Inspect for visible damage to compressor, coils, and fans.
   4. Inspect internal insulation.
   5. Verify that labels are clearly visible.
   6. Verify that clearances have been provided for maintenance.
   7. Verify that controls are connected and operable.
   8. Verify that filters are installed.
   9. Clean condenser coil and inspect for construction debris.
   10. Clean furnace flue and inspect for construction debris.
   11. Connect and purge gas line.
   12. Remove packing from vibration isolators.
   13. Verify lubrication on fan and motor bearings.
   14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   15. Adjust fan belts to proper alignment and tension.
   16. Start unit according to manufacturer's written instructions.
      a. Start refrigeration system.
      b. Do not operate below recommended low-ambient temperature.
      c. Complete startup sheets and attach copy with Contractor's startup report.
   17. Inspect and record performance of interlocks and protective devices; verify sequences.
   18. Operate unit for an initial period as recommended or required by manufacturer.
   19. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
      a. Measure gas pressure on manifold.
      b. Inspect operation of power vents.
      c. Measure combustion-air temperature at inlet to combustion chamber.
      d. Measure flue-gas temperature at furnace discharge.
      e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
      f. Measure supply-air temperature and volume when burner is at maximum firing rate (at simulated minimum outside air temperature) and when burner is off. Calculate useful heat to supply air.
   20. Calibrate thermostats.
   21. Adjust and inspect high-temperature limits.
   22. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers. (in conjunction with contractor supplying local controller)
   23. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
      a. Coil leaving-air, dry- and wet-bulb temperatures.
      b. Coil entering-air, dry- and wet-bulb temperatures.
      c. Outdoor-air, dry-bulb temperature.
      d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
   24. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown. (in conjunction with contractor supplying local controller)
   25. Measure and record the following minimum and maximum airflows and plot fan volumes on fan curve. This is to be done by a Testing and Balance Certified Contractor according to Division 15 requirements.

a. Supply-air volume.
b. Return-air volume.
c. Relief-air volume.
d. Outdoor-air intake volume.

26. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.
28. After startup and performance testing and prior to substantial completion, replace existing filters with new filters.

I. Occupancy Adjustments: When requested within 12 months of date of substantial completion provide on-site assistance by a factory authorized service representative in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION AND COMMISSIONING

A. Arrange for a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, maintenance, preventative maintenance, and how to obtain replacement parts. The training will occur after the startup report has been provided to the Owner. The trainer shall provide four (4) Installation and Operations Manuals (IOM) for the use of the Owner’s personnel during training. Training shall also follow the requirements of Division 1 Operation and Maintenance and Demonstration and Training Sections.

B. Review data to familiarize Owner’s personnel with contents of IOM and Operating and Maintenance Data specified in Division 1 "Project Closeout". All required and recommended maintenance shall be reviewed as well as operational troubleshooting. Provide a written troubleshooting guide if the IOM does not include one.

C. Schedule training with Owner, through AOR/EOR, with at least seven days' advance notice.

D. Demonstrate proper operation of equipment to commissioning agent or designated Owner’s personnel. The scope of the demonstration shall include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 1 and 15. Manufacturer’s representative shall participate in all commissioning activities related to the CBRTU, including demonstration by contractor supplying local controller.

E. Factory test all sequences of operation prior to shipping.

END OF SECTION 15781