

SECTION 23 0700 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Flexible elastomeric.
 - b. Mineral fiber.
2. Duct Fire Wrap
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Sealants.
7. Field-applied jackets.
8. Removable insulation covers.
9. Tapes.
10. Securements.
11. Corner angles.

B. Related Sections:

1. Section 23 2113 "Hydronic Piping."
2. Section 23 2116 "Hydronic Piping Specialties."
3. Section 23 2123 "Pumps."
4. Section 23 2213 "Steam Piping."
5. Section 23 2216 "Steam Piping Specialties."
6. Section 23 3114 "Ductwork."
7. Section 23 5214 "Primary Heating Equipment."
8. Section 23 8216 "Coils."
9. Section 23 8413 "Humidification Equipment."

1.2 SUBMITTALS

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

B. ***LEED Submittal:***

1. ***Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.]***

C. 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, linkages of control devices, 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 field application for each equipment type.

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. 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.

B. Materials and installation in accordance with NFPA 255, UL 723, and MICA (Midwest Insulation Contractors Association).

C. Insulation thickness shall meet the requirements of ASHRAE Standard 90.1 and shall be selected to eliminate avoid condensation.

1.4 SPECIAL WARRANTIES

A. Five (5) years, see Division 01.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

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

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

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

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

- F. 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.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex (Preferred).
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
- 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.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Atmosphere Duct Wrap.
 - d. Owens Corning; All-Service SOFTR Duct Wrap.
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or 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.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; CertaPro Commercial Board.
 - b. Johns Manville; 800 Series Spin-Glas.
 - c. Knauf Insulation; Insulation Board.
 - d. Owens Corning; Fiberglas 700 Series.
- I. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Micro-Lok.
 - b. Knauf Insulation; Redi-Klad 1000 Pipe Insulation.
 - c. Owens Corning; Fiberglas Pipe Insulation.
 2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Densities per PART 3 schedules.
- J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, provide one of the following:

- a. Johns Manville; Fabrication Board.
- b. Knauf Insulation; Pipe and Tank.
- c. Owens Corning; Pipe and Tank.

2.2 Grease Duct Insulation

- A. Products: Subject to compliance with requirements, provide one of the following:
1. 3M Fire Barrier Duct Wrap Type 15A
 2. UNIFRAX Fyrewrap
 3. Thermal Ceramics Firemaster
- B. Joint free, lightweight, non-asbestos, high temperature, inorganic foil encapsulated ceramic fiber blanket duct wrap for use on commercial grease hood duct systems in accordance with ASTM E2336.
- C. A zero inch clearance to combustible construction and two (2) hour fire resistive rated enclosure system shall be assured.
- D. Adhesives: High performance filament tape, one inch wide, and aluminum foil tape to seal cut edges of blankets.
- E. Banding Material: Two (2) hour requirement, 3/4" wide, no less than 0.015 inches thick, Type 304 stainless steel, (stainless steel hose clamps, 1/2 inch may be substituted for hanger insulations only).
- F. Insulation Pins: 10 gage, 4 inches to 5 inches long, copper coated steel no less than 1-1/2 inch by 1-1/2 inch or 1-1/2 inch diameter galvanized steel speed clip.
- G. Fire Stopping Materials: UL No R9464 classified noncombustible fiber with a flame spread of 0, smoke development of 0 and fuel contribution of 0. Water based, mild chemical resistant putty complying with ASTM E136-82 may be used.

2.3 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
1. Products: Subject to compliance with requirements, provide one of the following:
- 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.

2.4 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Adhesives to be waterproof fire-retardant type.

C. ***[Retain subparagraph below if low-emitting materials are required for LEED-NC Credit EQ 4.1.***

1. ***For indoor applications, use adhesive for Flexible Elastomeric, ASJ, and PVC Jacket that has a VOC content of 50 g/L or less and for Mineral-Fiber Adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).]***

2.5 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.

2.6 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, 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.
5. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacketing and Pre-Formed Fitting Covers: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; roll stock ready jacketing for shop or field cutting and forming, and pre-formed fitting covers. Thicknesses as indicated in field-applied jacket schedules.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston (Preferred), 300 Series if outdoors, 2000 series if indoors.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 5. Factory-fabricated tank heads and tank side panels.
- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metals Corporation; Surefit.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Finish and thickness are indicated in field-applied jacket schedules.
 3. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 REMOVABLE INSULATION COVERS

A. Acceptable Manufacturers:

1. Advance Thermal Corp.
2. Thermal Energy Products, Inc.
3. Temptec.
4. Remco Technology, Inc.

B. Removable ceramic blanket type with Velcro tabs and box-stitched, 1.5" wide, D-ring straps, gussets, hot face inner jacketing, type 304 stainless steel tag with laser engraved data riveted to body, outer jacketing, type 304 stainless steel quilting pins, specifically shaped and constructed for insulated item.

2.10 TAPES

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fason 0835.
 - b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Bilrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fason 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Bilrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

2.11 SECUREMENTS

- A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.
- B. Insulation Pins and Hangers:
 1. 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.
 2. 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.
 3. 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.
- C. Wire: 0.062-inch soft-annealed, stainless steel.

2.12 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. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. 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.

3.2 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 (all cold work at a minimum, and it shall be continuous), 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.
 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.

3.3 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 07 Section "Penetration Firestopping."
- 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 07 Section "Penetration Firestopping."
- G. 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. Fabricate boxes from aluminum, at least 0.050 inch thick.
 3. 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.

3.4 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.
- 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, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- 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. 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.

3.5 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.

3.6 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 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 and 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.
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 over-compress 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. 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. For Blanket Insulation 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. For Board Insulation, 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.
8. 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

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

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

B. 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.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant

recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES

- A. Duct, Equipment, and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 Painting Sections.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. 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 three location(s) 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 three location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
 - 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 Insert number 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.

3.10 DUCT INSULATION SCHEDULE, GENERAL **[EOR TO FINAL DETERMINE ALL]**

- A. Plenums and Ducts Requiring Insulation: **[EDIT TO MATCH 3.11 AND BEYOND FOR EACH JOB]**

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

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
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.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE [EOR TO FINAL DETERMINE ALL]

- A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- B. Exposed (in finished spaces), Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- C. Concealed, Return-Air Duct and Plenum Insulation: ~~XXXX~~.
- D. Concealed, Outdoor Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- E. Exposed in Unconditioned Spaces or Mechanical Rooms, Supply-Air, Return-Air, and Outdoor Air Duct and Plenum Insulation: Mineral-fiber board, 1 inches thick and 3-lb/cu. ft. nominal density.
- F. Concealed or Exposed Exhaust and Relief Between Isolation Damper and Penetration of Building Exterior, and Within 20' of the Building Exterior: Mineral-fiber blanket, 2 inches thick and 0.75-lb/cu. ft. nominal density.
- G. Kitchen Hood exhaust ducts shall be insulated with minimum 2-hour rated grease duct wrap.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE [EOR TO FINAL DETERMINE ALL]

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Exposed, Supply-Air and Return-Air Duct and Plenum Insulation: Mineral-fiber board, 3 inches thick and 6-lb/cu. ft. nominal density.

3.13 EQUIPMENT INSULATION SCHEDULE [EOR TO FINAL DETERMINE ALL]

- 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 is not factory insulated.
- C. Circuit Setters: Insulate with pre-formed insulation sections specifically designed for the specific circuit setters, and adjacent piping insulation and jacketing shall butt to same, and be sealed.
- D. Heat-Exchangers Insulation: Removable insulation covers.
- E. Heating-Hot-Water Pump Insulation: Mineral-Fiber Board/Pipe and Tank: 2 inches thick and 3-lb/cu. ft. nominal density.
- F. Chilled-water air-separator insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
 - 2. Mineral-Fiber Pipe and Tank: 1 inch thick.
- G. Re-heat Coils: VAV and FPVAV reheat coil sections shall have field installed insulation, coving the exposed coil u-bends on both sides of the coil section, coil headers, and the entire reheat section.
- H. See 3.19 through 3.22 below also.

3.14 PIPING INSULATION SCHEDULE, GENERAL [EOR TO FINAL DETERMINE ALL DEPENDING ON CAMPUS, ETC]

- 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.]

3.15 INDOOR PIPING INSULATION SCHEDULE [EOR TO FINAL DETERMINE ALL DEPENDING ON CAMPUS, ETC]

- A. Chilled Water and Refrigerant Suction: Insulation shall be one of the following:
 - 1. Flexible Elastomeric
 - 2. Mineral-Fiber, Preformed Pipe, Type I
 - 3. Insulation Density (if Mineral-Fiber): **XXX**
 - 4. Insulation Thickness
 - a. **XXX**
- B. Heating-Hot-Water Supply and Return: Insulation shall be:
 - 1. Mineral-Fiber, Preformed Pipe, Type I
 - 2. Insulation Density: **XXX**
 - 3. Insulation Thickness
 - a. **XXX**

C. Exposed Hot-Gas Piping. Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness

a. **XXX**

D. Low Pressure Steam and Steam Condensate: Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness

a. **XXX**

E. HP Steam and Steam Condensate: Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness

a. **XXX**

F. Pipe insulation subject to maintenance personnel traffic or within 60" of the floor in mechanical type spaces shall be minimum 12 pcf density (with a maximum conductivity of 0.45 BTU - inch/(hr-sf-F) at 100°F) and is to be PVC (30 mil thick Series 300) or metal jacketed with waterproof seams and joints. Thicknesses to be as follows (thickness derived normally from ASHRAE 90.1-2007/required thickness): (1"/2").

G. Cooling Coil Condensate Piping: **XXX**

H. Condenser Water Piping: No Insulation Required.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE [EOR TO FINAL DETERMINE ALL DEPENDING ON CAMPUS, IN-FORCE ASHRAE 90.1 VERSION, IN-FORCE IMCC VERSION, ETC]

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: Minimum 20 mils thick.
2. Aluminum, Smooth or Corrugated or Stucco Embossed: Minimum 0.016 inch thick.

3.17 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE [EOR TO FINAL DETERMINE ALL DEPENDING ON CAMPUS, ETC]

A. Chilled Water and Refrigerant Suction: Insulation shall be one of the following:

1. Flexible Elastomeric
2. Mineral-Fiber, Preformed Pipe, Type I

3. Insulation Density (if Mineral-Fiber): **XXX**
4. Insulation Thickness
 - a. Pipe Size 1" and less = **X"**
 - b. Pipe Size 1 ½" and up = **X"**

B. Heating-Hot-Water Supply and Return, 200 Deg F and below: Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness
 - a. All Pipe Sizes = **X"**

C. Low Pressure Steam and Steam Condensate: Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness
 - a. **XXX**

D. HP Steam and Steam Condensate: Insulation shall be:

1. Mineral-Fiber, Preformed Pipe, Type I
2. Insulation Density: **XXX**
3. Insulation Thickness
 - a. **XXX**
4. See additional requirements in 23 0700, 3.24.

E. **Cooling Coil Condensate (if heat traced): XXX**

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE [EOR TO FINAL DETERMINE BASED ON SERVICE, CAMPUS, ETC.]

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket. Installation to be waterproof.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 1. Aluminum, Smooth or Corrugated or Stucco Embossed: Minimum 0.016 inch thick.
- D. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
 1. Aluminum, Smooth or Corrugated or Stucco Embossed: Minimum 0.032 inch thick.
- E. Piping, Exposed:

1. PVC: 30 mils thick.
2. Aluminum, Smooth or Corrugated or Stucco Embossed: Minimum 0.016 inch thick.

3.19 REMOVABLE INSULATION COVERS

- A. Use to cover steam valves, chilled water valves, heating hot water valves, steam expansion joints, condensate pump package receivers, heat exchanger faces, flash tanks, hurling tanks and similar vessels, and awkward surfaces not covered by insulation.

3.20 COLD HYDRONIC PUMP INSULATION

- A. Each pump to be covered by minimum of 1" thick AP Armaflex (or thicker to eliminate condensation) applied with a waterproof adhesive. Removable components shall use Velcro applied to both the pump body and the insulation with waterproof adhesive such that pieces can be removed for servicing and inspection and re-installed without damage.

3.21 HOT PUMP INSULATION

- A. Each pump to be covered by minimum of 1" thick fiberglass pipe and tank insulation applied with a high temperature adhesive and finish jacketing and banding/wiring. Removable components shall use Velcro applied to both the pump body and the insulation with high temperature adhesive such that pieces can be removed for servicing and inspection and re-installed without damage.

3.22 CHILLER INSULATION

- A. Each chiller to be covered by minimum of 1" thick AP Armaflex (or thicker to eliminate condensation) applied with a waterproof adhesive. Removable components shall use Velcro applied to both the pump body and the insulation with waterproof adhesive such that pieces can be removed for servicing and inspection and re-installed without damage.

3.23 CONVERTOR INSULATION

- A. Each convertor to be covered by removable insulation covers such that pieces can be removed for servicing and inspection and re-installed without damage (for heat exchanger face only).

3.24 INSULATION FOR STEAM AND CONDENSATE PIPING

- A. Provide piping and equipment insulation as manufactured by Owens-Corning, CertainTeed, Knauf, or John Manville or as indicated. Insulation shall be UL listed with flame spread / fuel contributed/ smoke developed rating of 25/50/50 in accordance with ASTM E84, NFPA 90A, NFPA 255 and UL 723.
- B. Low pressure condensate return piping shall be insulated with Owens Corning SSL-II fiberglass pipe insulation with factory applied all service vapor barrier jacketing. Provide PVC pipe fittings filled tightly with fiberglass. Insulation K factor shall be minimum of 0.23 at 75°F per ASTM C335.
- C. High pressure steam and condensate return piping within buildings shall be insulated with 1200°F rated mineral wool piping insulation ASTM-C547 with factory vapor barrier jacket.
- D. Provide stainless steel jacketing over factory vapor barrier covering for all piping in the vaults for entire straight lengths and jacket over PVC elbow and valve covers. Refer to specification of

stainless steel coverings below. Insulation K factor shall be minimum of 0.23 at 75°F per ASTM C335. Thickness shall be 1.5" for piping up to 4" and 2" thick for piping 5" and larger. Provide calcium silicate 120° segment at points of support (under insulation protection shield). Insulation protection shield shall be installed over stainless steel jacketing.

- E. High pressure steam and condensate return piping within vaults shall be insulated using IIG (Industrial Insulation Group, LLC) thermo-12 gold pre- formed, 1200°F rated pipe and block insulation composed of hydrous calcium silicate which is inorganic, non-combustible, and meets ASTM C533 and ASTM C411, Type 1. Thermal conductivity shall be 0.45 btu*in/(hr*ft*f)at 300°F. Cover all insulated piping and fittings withing vault with stainless steel jacketing (see below).

1. Insulation thicknesses shall be as follows:

Fluid design operating temperature range, f	Nominal pipe diameter (in.)				
	< 1"	1" to < 1½"	1½" to < 4"	4" to < 8"	8" & up
Above 350°	4.5	5.0	5.0	5.0	5.0
251°-350°	3.0	4.0	4.5	4.5	4.5
201°-250°	2.5	2.5	2.5	3.0	3.0
100°-200°	1.5	1.5	2.0	2.0	2.0
40°-60°	1.5	1.5	1.5	1.5	1.5
Up to 39°	1.5	1.5	2.0	2.0	2.0

The table is based on ASHRAE 90.1-2013 and IMCC-2012. Insulation for pipe service 40-60F and <40F exceeds the requirements of ASHRAE 90.1 and IECC for condensation purposes.

- F. If physical constraints will not allow the above thicknesses to be installed, contractor shell provide an equivalent insulating value thickness of Pyrogel XTF. Cover insulation with minimum 2 coats of wettable fabric.
- G. Insulation shall be applied using manufacturer approved material and methods. Adhesives shall be waterproof retardant type in compliance with ASTM E84, NFPA 255 and UL 723.
- H. No insulation shall be applied until after the system has been properly tested in presence of owner's representative. Ductwork shall be sealed, tested and proved air tight prior to insulation application.
- I. No piping shall be insulated until pressure testing has been completed and accepted by the owner.
- J. Insulate all valves and pipe fittings except omit insulation on the following: unions, traps and strainer blow-off valves.
- K. Pipe fittings shall be covered with same thickness of insulation as the pipe and wrapped with wettable cloth fabric and sealed with approved adhesive.
- L. Equipment to be insulated shall include all equipment which is a part of the piping system. Such includes but is not limited to: flash tanks.
- M. New and existing insulated piping within manholes shall be enclosed with 304 stainless steel jacket with prefabricated stainless steel fitting covers. Jacket shall be provided with stainless steel straps at 12" O.C. seams shall be arranged to shed water, shall overlap shall be caulked with weather resistant industrial quality clear sealant. Jacket thickness shall be 0.16" up to 6" O.D. (including insulation) and 0.20" thick for piping with O.D. greater than 6". Metal jacketing shall be by ITW (ITWINSINSULATIONS.COM) or equal. Cover all valves and fittings located outside with same insulation type and thickness as piping. Installed custom fabricated or pre-fabricated valve

jacketing covering entire valve and leaving only operating handle. Seal water tight with mastiques and sealant such that no insulation can become wet. Aluminum jacketing and PVC covers within manholes are not acceptable. Use of PVC covers within manholes is prohibited.

- N. PVC fitting covers (see below) shall be used in mechanical rooms.
- O. PVC factory insulation fitting and straight pipe covers for pipe fittings and valves: proto "Losmoke" fabricated of ASTM 1784 polyvinyl chloride. 160°F rated with 25/50 fire/smoke rating per ASTM E-84, bright gloss white. Fitting covers shall be commercial grade thickness. "light gauge" commercial thickness covers are not acceptable. Install covers using manufacturer-furnished adhesive mastic and sealant. Contractor shall use cover manufacturer furnished fiberglass insulation inserts for each specific application with fiberglass having $k=0.26$ at 75°F per ASTM C177. All fitting covers shall be one-piece. Space between PVC covers and piping shall be filled tightly with insulation.
- P. Cover thickness shall be as follows:
1. Circumference including overlap up to 9", cover thickness 0.020
 2. Circumference including overlap up to 9.5" to 13", cover thickness 0.030.
 3. Circumference including overlap up 14" and larger, cover thickness 0.040
- Q. When connecting new piping to existing piping within manhole existing insulation covering entire straight run of pipe to which new piping connects shall be stripped of the existing insulation and new insulation and jacketing in accordance with the specification shall be provided to the entire straight piece of existing pipe to which new pipe connects.
- R. Where anchor is installed in the existing piping in the existing manhole, the straight run of pipe to which anchor is installed shall be stripped of existing insulation and new insulation and jacketing in accordance with the specification shall be provided to straight pipe.
- S. Valves shall be insulated entirely leaving only stem and handle. Valves shall be operable without disturbing insulation. Should the insulating contractor notice that the valves installed by mechanical contractor cannot be properly insulated due to lack of extended handle, insulating contractor shall not insulate such valves until proper size handle has been installed by mechanical contractor. Do not insulate pipe unions and steam traps. Provide neat 45 degree taper at each side of union or trap.
- T. Insulation shall be sealed with manufacturer's approved sealant and shall have neat finished appearance. No exposed insulation shall be visible.

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PROJECT NAME _____
JOB # _____

FOR: _____
ISSUED: 11/06/2018

- U. At wall penetrations by high pressure steam piping provide calcium silicate ASTM C533 rigid white insulation

END OF SECTION 23 0700