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PART 1 - INTRODUCTION

- A. This section pertains to insulation requirements for duct, pipe, and equipment for both building and utility systems. Building insulation standards are followed by utility insulation standards.

PART 2 - DUCT INSULATION FOR BUILDING SYSTEMS

2.1 General Duct Insulation Requirements

- A. Purpose
 - 1. Provide insulation for energy conservation, personnel protection, condensation control, freeze protection, noise control, and fire protection.
- B. This Section specifies the requirements for materials and application of insulation to ducting, and equipment which is not pre-insulated as part of a packaged system.
- C. Flame/Smoke Spread Ratings: composite ratings of 25/50 per ASTM E84, UL 723, and NFPA 255.
- D. OSHA: Comply with OSHA requirements for materials, accessories, and personnel protection.
- E. Design insulation systems based on the minimum following guidelines
 - 1. Governing Code requirements
 - 2. SMACNA Guidelines
 - 3. ASHRAE Fundamentals Handbook – Insulation for Mechanical Systems
 - 4. ASHRAE Energy Standards 90.1 and 189.1: Comply with ASHRAE where insulation requirements are more restrictive than indicated in this Specification.
 - 5. LEED Requirements
 - 6. Mechanical Insulation Design Guide by the National Mechanical Insulation Committee.
 - 7. Thermal values to prevent condensation.
 - 8. NFPA requirements
 - 9. Appropriate vapor and water barriers.
- F. Systems requiring insulation, but not limited to are:
 - 1. Supply duct, heating and cooling
 - 2. Return duct, heating and cooling

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3. Outdoor air duct and plenums
4. Louver blank-off section at outdoor intakes
5. Kitchen exhaust duct
6. Equipment part of water and air distribution systems.

G. Installation Requirements

1. Labeling and flow arrows complying with Mechanical Identification requirements shall be applied to the exterior surface of insulation systems.
2. Insulation shall be continuous through wall and ceiling openings.
3. For outdoor applications duct shall slope away from equipment which it connects to, and at locations where it enters or exits a structure.
4. Provide insulation stand-offs, for volume damper handles and similar devices.
5. At location of duct supports and hangers, there shall be a rigid thermal break to prevent the compression of insulation. Rigid thermal break shall be of sufficient thermal resistance to prevent internal and external condensation.
6. At locations such as access doors, and where equipment must be accessed, insulation shall be removable and be replaceable without compromising the integrity of the insulation and vapor barrier system.
7. Insulation shall not be installed prior to duct leakage and associated equipment testing.

H. Insulation Securement Requirements.

1. Duct insulation shall be secured with the use of PBH Dynastick Mechanical Type Fastener insulation hanger and adhesive, regardless of surface orientation, and area.
2. For kitchen exhaust systems, manufacturer instructions shall govern external insulation fastening requirements.


I. Internal lining of duct.

1. Exposed internal lining of duct is prohibited for the purpose of insulation. For the purpose of sound attenuation, internal lining of duct shall be allowed pending approval by Yale. Where duct is internally lined for attenuation purposes, this shall not omit the requirement of external insulation.

J. Outdoor Insulation Requirements

1. Outdoor duct shall be round double-wall, gasketed, and insulated between inner and outer layer of ducts.
2. Where round double-wall insulated duct is not feasible for outdoor applications, insulate rectangular duct as outlined within the corresponding section of this standard.

2.2 Duct Insulation Minimum Requirements Building Systems


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A. External Duct Insulation

1. Materials:
 - a. Type A: flexible glass fiber insulation, thickness as scheduled, 3/4-pcf density, with UL-labeled foil vapor barrier. Thermal conductivity shall be no greater than 0.31 Btu-inch per hour-ft² degrees F at 75 degrees F.
 - b. Type B: rigid glass fiber insulation per ASTM C612, thickness as scheduled, 3-pcf density, with UL-labeled, foil-reinforced, kraft-faced vapor barrier. Thermal conductivity shall be no greater than 0.23 Btu-inch per hour-ft² degrees F at 100 degrees F.
 - c. Type C: rigid glass fiber insulation per ASTM C612, thickness as scheduled, 6-pound density with UL-labeled, foil-reinforced, kraft-faced vapor barrier.
 - d. Type D: foamed plastic of closed cell structure, thickness as scheduled. Thermal conductivity no greater than 0.28 Btu-inch per hour-ft² degrees F at 75 degrees F and maximum water vapor transmission rating of 0.1 perms.

2. General:
 - a. Install materials in accordance with the manufacturer's instructions.

3. External Duct Insulation Minimum Installation Requirements (Types A, B, C and D):
 - a. Application:
 - 1) Secure insulation to ductwork using a combination of adhesive and mechanical fasteners, such as impale anchors.
 - 2) Install without sag on the underside of ductwork using a combination adhesive and mechanical fasteners. Bend over nail tips after installation of washers to facilitate sealing of vapor barrier and to preclude injury. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
 - 3) Lap joints and seams of external of batt type insulation a minimum of 3 inches overlap 3 inches on center. Secure as required.
 - 4) Seal insulation with vapor barrier adhesive or tape matching jacket type to maintain the vapor barrier. Pay particular attention to penetrations by mechanical fasteners, joints, seams and to ends and edges.
 - b. Rigid Insulation: Band insulation 12 inches on centers.
 - c. Outdoor ducts: Cover insulation with Polyguard, or equal product.
 - d. The top surface of all exterior exposed ductwork shall be sloped and capped with galvanized sheet metal constructed with waterproof seams and joints. Turn down edges over sides of ducts a minimum of 2". Secure cap with stainless steel or aluminum straps that fully encircle duct. Provide sheet metal insulation reinforcement at corners to prevent straps from crushing insulation. Paint galvanized cap per project requirements.

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4. Ductwork Insulation Schedule

Duct Location	Insulation Type	Minimum Insulation Thickness (Inches)	Comments
Conditioned Spaces: Concealed Exposed	A C	1-1/2"	
Non-Conditioned Spaces: Concealed Exposed	A C	1-1/2"	
Outside	D	2	(Note 1)
Toilet room exhaust ductwork	E	1	Lined 15 feet downstream of exhaust grilles
Louver blankoff sections	C	1	Maintain vapor barrier
Insulated duct support, for thermal break	C	To match insulation thickness	6-inch-wide continuous strip (Note 2)
Terminal Unit: Inlet Duct Outlet Duct	A E	1-1/2" 1"	Lined 5 feet downstream of box

Notes:

- 1.) "Fresh Air" intake ducts require no insulation when located outdoors.
- 2.) Install at hanger supports serving externally insulated ductwork.


B. Internal Duct Liner (Type E):

1. Materials:
 - a. Type E: flexible duct liner insulation, thickness as scheduled, 2.0-pound density with fire-resistant fiberglass mat coating on the air side rated for maximum 5,000-fpm air velocity. Thermal conductivity shall be no greater than 0.25 Btu-inch per hour-ft² degrees F at 75 degrees F.
2. Acoustical Performance:
 - a. Acoustical performance shall be determined with a Type F25 mounting in accordance with ASTM C423.
 - b. Minimum acoustical performance shall be as follows:

Sound Absorption Coefficient at Frequency

Insulation Type	Thickness (inches)	125	250	500	1,000	2,000	4,000	NRC
E	1	0.26	0.59	0.68	0.85	0.89	0.87	0.75

3. General:

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- a. Apply liner in accordance with the SMACNA Duct Liner Application Standard.
- 4. Application:
 - a. Apply internal insulation to flat sheet metal with continuous coverage of adhesive. Use adhesive on all butted edges. Install clip-pins at 15 inches on center and no more than 2 inches maximum from any cut or exposed edge. Select pin length based on the liner manufacturer's recommendations. Use of nail-type fasteners is prohibited.
- 5. Dimensions:
 - a. Duct dimensions shown are net inside dimension. Increase the size of sheet metal to allow for liner thickness.
- 6. Plenums:
 - a. Provide 1-inch mesh hardware cloth facing over attenuated plenum floors.
- 7. Nosing Strips:
 - a. Provide nosing strips at each joint in the duct liner where air velocities exceed 1,500 fpm, at cut edges in lined plenums, at leading edges on air intakes, and where noted or otherwise specified.


PART 3 - PIPE INSULATION FOR BUILDING SYSTEMS

3.1 Piping Insulation

- A. Purpose
 - 1. Provide insulation for energy conservation, personnel protection, condensation control, freeze protection, noise control, and fire protection.
- B. This Section specifies the requirements for materials and application of insulation to piping, vessels, and equipment which is not pre-insulated as part of a packaged system.
- C. The following areas are covered:
 - 1. Hot surface insulation.
 - 2. Cold surface insulation.
 - 3. Sound control insulation.
- D. No asbestos containing material shall be specified.

3.2 DEFINITIONS

- A. Hot Surfaces: those surfaces with operating temperatures above ambient temperature (100F unless stated otherwise).

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- B. Cold Surfaces: those surfaces with operating temperatures below ambient temperature or dual-temperature surfaces which operate above and below ambient (100F unless stated otherwise).
- C. Fitting: designates elbows, tees, caps, reducers, miters, and stub-in connections.
- D. Thermal Conductivity: Units are Btu per hour per square foot per degrees F per inch.

3.3 REGULATORY REQUIREMENTS


- A. Flame/Smoke Spread Ratings: composite ratings of 25/50 per ASTM E84, UL 723, and NFPA 255.
- B. Energy Codes: Comply with ASHRAE 90.1 where insulation requirements are more restrictive than indicated in this Specification.
- C. OSHA: Comply with OSHA requirements for materials, accessories, and personnel protection.

3.4 PIPE INSULATION MINIMUM PRODUCT REQUIREMENTS


- A. Fiberglass:
 1. Acceptable Manufacturers:
 - 1) Schuller.
 - 2) Owens Corning.
 - 3) Knauf.
 2. Type FG1 - Preformed Pipe Insulation, Jacketed:
 - a. Description: sectional complying with ANSI/ASTM C547.
 - b. Thermal Conductivity: 0.23 at 75 degree F mean temperature.
 - c. Jacket: factory-applied kraft-reinforced foil vapor barrier, all-service jacket with self-sealing lap seal.
 - d. Maximum Operating Temperature: 850 degrees F.
 3. Type FG2 - Semirigid, Jacketed:
 - a. Description: roll form complying with ANSI/ASTM C612.
 - b. Thermal Conductivity: 0.27 at 75 degree F mean temperature.
 - c. Jacket: factory-applied kraft-reinforced foil vapor barrier, all-service jacket with self-sealing lap seal.
 - d. Density: 3 pcf.
 - e. Maximum Operating Temperature: 850 degrees F.
 4. Type FG3 - Semirigid, Jacketed, Low Temperature:
 - a. Description: roll form complying with ANSI/ASTM C553.
 - b. Thermal Conductivity: 0.24 at 75 degree F mean temperature.
 - c. Jacket: factory-applied foil-reinforced scrim kraft, vapor barrier jacket with

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- self-sealing lap seal.
 - d. Density: 6 pcf.
 - e. Maximum Operating Temperature: 450 degrees F.
 - 5. Type FG4 - Flexible Blanket, Nonjacketed, High Temperature:
 - a. Description: roll form complying with ANSI/ASTM C553.
 - b. Thermal Conductivity: 0.27 at 75 degree F mean temperature.
 - c. Density: 2 pcf.
 - d. Maximum Operating Temperature: 1,000 degrees F.
 - 6. Type FG5 – Rigid, Jacketed:
 - a. Description: rigid insulation board per ASTM C612
 - b. Thermal Conductivity: 0.23 at 75 degrees F mean temperature.
 - c. Jacket: factory applied foil-reinforced, kraft-faced vapor barrier.
 - d. Density: 6 pcf.
- B. Thermal Insulating Wool:
- 1. Acceptable Manufacturers:
 - a. U.S. Gypsum.
 - b. Rock Wool Industries.
 - c. Bradford Enercon.
 - 2. Type W1 - Flexible Blanket, Wire Mesh:
 - a. Description: roll form with 1-inch wire mesh each side complying with ANSI/ASTM C553.
 - b. Thermal Conductivity: 0.27 at 75 degree F mean temperature.
 - c. Density: 8 pcf.
 - d. Maximum Operating Temperature: 1,000 degrees F.
 - 3. Cellular Glass:
 - a. Acceptable Manufacturer:
 - 1) Pittsburgh Corning Foamglas.
 - b. Type G1 - Preformed Pipe and Block:
 - 1) Description: flat block or half-round incremental lengths of cellular glass complying with ANSI/ASTM C552, Type II, presized for nominal pipe sizes.
 - 2) Thermal Conductivity: 0.33 at 75 degree F mean temperature.
 - 3) Density: 8 pcf.
 - 4) Maximum Operating Temperature: 900 degrees F.

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- 5) Water Vapor Permeability: less than 0.005 perm-inch.
4. Flexible Elastomeric:
 - a. Acceptable Manufacturers:
 - 1) Armstrong.
 - 2) Schuller.
 - b. Type E1 - Preformed Pipe and Sheet/Roll:
 - 1) Description: Comply with ANSI/ASTM C534, Types I and II.
 - 2) Thermal Conductivity: 0.27 at 75 degree F mean temperature.
 - 3) Flame Spread/Smoke Developed Rating: 25/50.
 - 4) Minimum/Maximum Operating Temperature: minus 40 to plus 220 degrees F.
 - 5) Water Vapor Permeability: 0.2 perm-inch.
 5. Hydrous Calcium Silicate:
 - a. Acceptable Manufacturer: Schuller.
 - 1) Type C1 - Preformed Pipe or Block:
 - a) Description: ridged, white, asbestosfree complying with ANSI/ASTM C533.
 - b) Thermal Conductivity: 0.4 at 300 degree F mean temperature.
 - c) Density: 15 pcf.
 - d) Maximum Operating Temperature: 1,200 degrees F.
 6. Foam:
 - a. Acceptable Manufacturer:
 - 1) Accessible Products Company, Techlite SSL879.
 - b. Type F1, Flexible Open-Cell Melamine:
 - 1) Description: pre-jacketed, preformed pipe or sheet insulation; fiberfree; low outgassing.
 - 2) Thermal Conductivity: 0.26 at 75 degree F mean temperature.
 - 3) Jacket: factory-applied hard, shiny gloss, rigid, high-impact PVC; 0.02 inch thick; white; 1-inch end overlap; with self-seal lap.
 - 4) Density: 0.6 to 0.7 pcf.
 - 5) Service Temperature: minus 150 degrees F to plus 400 degrees F; zero degrees F to 150 degrees F for jacket.
 - 6) Clean Zone Considerations: Vacuum insulation at factory to remove dust prior to packaging.


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- c. Type F2, Flexible Closed Cell:
 - 1) Description: foamed plastic of closed cell structure
 - 2) Thermal Conductivity: 0.28 at 75 degree F mean temperature.
 - 3) Vapor Transmission: 0.1 perms
 - 4) Jacket: field applied, coat with mastic, wrap with fiberglass, apply finish coat of mastic.

3.5 PIPE INSULATION JACKETS MINIMUM REQUIREMENTS

- A. Acceptable Manufacturers:
 - 1. Schuller.
 - 2. Childers.
 - 3. Pittsburgh Corning.
- B. Type A - Vapor Barrier Jackets: kraft-reinforced foil vapor barrier with self-sealing lap.
- C. Type B - PVC:
 - 1. Description: one piece, ultraviolet resistant, polyvinyl chloride (PVC).
 - 2. Thickness: 0.02 cut and curled.
 - 3. Flame Spread Rating: 25 or less.
 - 4. Smoke Developed Rating: 50 or less.
 - 5. Grade: weatherable.
 - 6. Color: white.
 - 7. Temperature Limits: zero to 150 degrees F.
- D. Type C - Canvas: UL-listed treated cotton fabric, 6-ounce-per-square-yard density.
- E. Type D - Aluminum: aluminum alloy 3003-H-4 or 5005-h14 with factory-applied moisture barrier as listed below:

Insulated Item	Thickness (Inch)	Finish
Piping	0.016	Smooth or embossed
Vessels and equipment shells 36-inch diameter and smaller	0.016	Smooth or embossed
Vessels and equipment above 36-inch diameter	0.032	Smooth, embossed, or corrugated
Vessels and equipment heads, vessel transitions, and stiffener rings	0.032	Smooth

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F. Type E, Stainless Steel - Type 304 stainless steel as listed below:

Insulated Item	Thickness (Inch)	Finish
Piping	0.016	Smooth or embossed
Vessels and equipment shells 36-inch diameter and smaller	0.016	Smooth or embossed
Vessels and equipment above 36-inch diameter	0.020	Smooth, embossed, or corrugated
Vessels and equipment heads, vessel transitions, and stiffener rings	0.032	Smooth

3.6 ACCESSORIES

A. Insulation Bands:

1. Galvanized Steel: 3/4 inch wide by 0.02 inch thick.
2. Stainless Steel, 24-Inch Diameter or Less: 1/2 inch wide by 0.015 inch thick, Type 304.
3. Stainless Steel, Larger Than 24-Inch Diameter: 3/4 inch wide by 0.02 inch thick, Type 304.
4. Heavy-Duty Stainless Steel: wing-type or crimp seals.

B. Metal Jacket Bands: Stainless Steel, 1/2 inch by 0.015 inch, Type 304.

C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.

D. Finishing Cement: ASTM C449.

E. Flashing Compound: high-temperature asphalt emulsion type suitable for flashing.

F. Glass Fabric: 10-by-10 open mesh, asphalt treated, 9 ounces per square yard.

G. Wire: 18-gauge stainless steel, Type 304, soft annealed, or 20-gauge galvanized steel as indicated.

H. Breather Springs: flat, spiral wound, Type 302 stainless steel.

I. Sheet Metal Screws: 1/2 inch long, No. 8, hex or pan head, stainless steel, self-tapping.

J. Expansion/Contraction Joints: loose mineral fiber blanket or resilient fiberglass blanket.

K. S Clips: Fabricate from 1-inch-wide by 0.032-inch Type 304 stainless steel.

L. Band Loops: Fabricate from 1/2-inch-wide by 0.015-inch-thick Type 304 stainless steel.


M. Insulation Tape: 3/4 inch wide, glass filament reinforced, pressure sensitive.

N. Expansion/Contraction Joint Tape: 4-inch-wide foil to kraft tape.

O. Weatherproof Mastic: asphalt emulsion type.

P. Adhesives: compatible with insulation.

3.7 EXECUTION

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A. INSPECTION


1. Verify that preparation work required before execution of work specified in this Section has been completed and is acceptable.
2. Notify Engineer in writing describing conditions that are not acceptable for installation of work specified in this Section. Recommend remedial work as necessary. Do not proceed with work of this Section until unacceptable conditions are corrected.

B. PREPARATION

1. Install materials after piping has been tested, inspected, and approved, or leave all joints and welds exposed until testing, inspection, and approval have been completed.
2. Coordinate painting of piping surface prior to insulation where required.
3. Clean surfaces to be insulated.
4. Install heat tracing where specified before insulating.
5. Keep insulating materials clean, dry, and free of dents and abrasions.
6. Protect insulating materials from moisture damage and do not apply wet materials. Remove wetted and reapply new insulation products.
7. Only insulation meeting ASTM C-795, chloride free, shall be utilized on stainless steel piping systems.

C. INSTALLATION

1. Applied Locations:
 - a. Requirements: Insulate piping and equipment as described in this Section.
 - b. Omit insulation as listed below unless noted otherwise on Contract Drawings; bevel and seal insulation ends at either side of the following:
 - c. Hot Piping Without Vapor Barrier:
 - 1) Flanges and unions.
 - 2) Valve bodies except where the fluid may solidify at ambient temperatures.
 - 3) Strainers
 - 4) Heat-traced valves, flanges, and unions located indoors.
 - 5) Tracer line loops and unions in tracers.
 - 6) Expansion and rotation joints, slide valves, steam traps, vents, and drains.
 - 7) Within 6 inches either side of vertical and horizontal piping supports without inserts.
 - 8) Within 6 inches either side of attachments to pipe.
 - d. Hot Vessels and Equipment:

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- 1) Manhole covers, nameplates, stampings, code inspection plates, nozzles, flanges, and weepholes.
- 2) Flanges on heat exchangers.
- 3) Channel and channel covers with sufficient clearance for bolt removal without damage to insulation and square rather than beveled edges.

e. Cold Piping with Vapor Barrier: relief valves.


D. Insulation:

1. Hot Piping:

- a. 36-Inch Diameter and Smaller:
- b. Material: single or multiple layer as required to develop thickness.
- c. Longitudinal Joints - Stagger and secure as follows:
 - 1) Outer Layer: Use galvanized wire ties on 9-inch centers.
 - 2) Inner Layer: Use two galvanized wire ties per section.
- d. Expansion Joints:
 - 1) Piping Above 500 Degrees F: 1 3/4 inches wide at 24-foot centers with joints in layers offset 12 inches on multiple-layer installations.
 - 2) Piping 500 Degrees F or Less: none required.
- e. Flange Bolt Clearance: sufficient to remove bolts without insulation damage with square cut edges.
- f. Fittings: Install prefabricated fitting covers or mitered sectional insulation material and wire in place prior to finishing.

2. Hot Vessels and Equipment:

- a. Vessels and Tubular Equipment 36 Inches and Smaller: Comply with requirements for hot piping.
- b. Vessels and Equipment Larger Than 36 Inches:
 - 1) Material: single or multiple layer as required to develop thickness.
 - 2) Longitudinal and Transverse Joints: Secure with stainless steel wire on 12-inch centers.
 - 3) Retainers: Secure with stainless bands or wire on 18-inch centers.
 - 4) Exposed Heads: Secure with bands attached to top floating ring and circumferential band at tangent line of head on 12-inch centers.
 - 5) Nonexposed Heads: Secure with stainless steel wire to manufacturer-installed supports.
 - 6) Stiffener Rings: Secure with stainless steel wire with band centered in each ring.
- c. Nontubular Equipment 36 Inches and Smaller: Comply with requirements for

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vessels and equipment larger than 36 inches.


3. Cold Piping:

a. 42-Inch Diameter and Smaller:

- 1) Material: single layer with insulation continuous through supports and with preformed metal insulation shields at outer surface.
- 2) Longitudinal Joints: staggered; coat edges with 1/16-inch-thick joint sealer; secure with tape 6 inches on center and within 1/2 inch of section ends.
- 3) Contraction Joints: fiberglass-packed 1 3/4 inch wide at 24-foot centers with locations offset 12 inches on double-layer installations and outside vapor sealed with contraction joint tape.
- 4) On any insulation that is capable of absorbing moisture, seal circumferential joints with waterproof mastic every 40' to keep water migration to a minimum (including area contacting pipe).
- 5) Flange Bolt Access: sufficient to remove bolts without insulation damage with square cut edges.
- 6) Fittings: prefabricated fitting covers or mitered sectional insulation material wired in place prior to finish.

4. Cold Vessels and Equipment:

- 1) Vessels and Tubular Equipment 36 Inches and Smaller: Comply with requirements for cold piping.
- 2) Vessels and Equipment Larger Than 36 Inches:
 - a) Material: single or multiple layer as indicated.
 - b) Longitudinal and Transverse Joints: Stagger joints, seal joint edges with 1/16-inch-thick layer of joint sealer, and secure with stainless steel insulation bands on 9-inch centers.
 - c) Contraction Joints: Provide 1-3/4-inch-wide fiberglass-packed joint at each insulation support ring, sealed with contraction joint tape.
 - d) Exposed Heads: Shape to fit head contour, seal joint edges with 1/16-inch-thick layer of joint sealer, and secure with stainless steel insulation bands attached to floating ring on top and circumferential band at tangent line with bands at 12-inch centers.
 - e) Nonexposed Heads: Install similar to exposed heads except secure insulation to attachments provided by equipment manufacturer.
 - f) Pumps, Compressors, and Other Irregularly Shaped Equipment: Enclose in block insulation, seal joint edges with 1/16-inch-thick layer of joint sealer, secure with stainless steel wire, and seal all joints vaportight, including bases.
 - g) Attachments: Extend insulation from vessel or equipment four

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times nominal thickness.

- h) Vapor Retarder Coating: Apply 1/16-inch-thick layer to outer surface prior to exterior finish, except for surfaces that receive mastic and glass fabric finish.
- 3) Nontubular Equipment 36 Inches and Smaller: Comply with requirements for vessels and equipment larger than 36 inches.


E. Jackets:

1. Indoor:

- a. Hot Piping, Vessels, and Equipment:
 - 1) Noncorrosive and Dry Areas: Type A, factory or field applied, or Type C, field applied and finished with insulating cement.
 - 2) Noncorrosive and Wet Areas: Type B or D, factory or field applied.
 - 3) Corrosive Areas: Type E, field applied.
- b. Cold Piping, Vessels, and Equipment:
 - 1) Noncorrosive and Dry Areas: Type A, factory or field applied to preformed insulation with continuous vapor seal.
 - 2) Noncorrosive and Wet Areas: Type B or D, field applied with continuous vapor seal.
 - 3) Corrosive Areas: Type E, field applied.

2. Outdoor: Piping, Vessels, and Equipment: Metal Jacketing (Type D/E)


- a. Straight Sections: Lap joints 2 inches and arrange to shed water with horizontal longitudinal seams located below centerline on the bottom third of pipe with seam lap facing down; secured with insulation bands on 9-inch centers or screws on 5-inch centers.
- b. Fittings: prefabricated metal covers to match jacket material with sealed longitudinal seam under pipe, secured with screws, and transverse joints covered with insulation bands.
- c. Open Insulation Ends: Cover with watertight metal flashing ring secured and weather sealed with flashing compound.
- d. Top Heads:
 - 1) Metal Jacketing: Install with 6 inches turned down on the straight side as lap and fasten to shell jacketing with screws on 5-inch centers.
 - 2) Circumferential Lap: Secure the head cover in place with stainless steel insulation band.
 - 3) Construct in manner to shed water.
- e. Irregularly Shaped Surfaces - Insulation Finish: Apply tack coat of weatherproof mastic and glass fabric followed by 1/8-inch-thick wet coat of

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- f. mastic with smooth finish over the glass fabric.
Seal circumferential joints with a coating recommended by the insulation manufacturer for weatherproofing.
- g. Pumps: Finish with removable metal enclosure fabricated for easy removal for maintenance and seal with specified mastic.

3.8 INSULATION SCHEDULE

<u>Pipe & Equipment</u>	<u>Size</u>	<u>Type</u>	<u>Minimum Thickness</u>	<u>Covering</u>
Domestic Cold Water Piping	Up to 1" Over 1"	FG1	½" 1"	Type D
Domestic Hot Water Piping	Up to 1- 1/2" Over 2"	FG1	1" 1-1/2"	Type D
Hot Water Heating Piping - Outdoor	Up to 2" Over 2"	FG1	1-1/2" 2"	Type D
Hot Water Heating Piping - Indoor	Up to 2" Over 2"	FG1	1-1/2" 2"	Type D
Chilled Water Piping – Outdoor	All	FG1	2"	Type B
Chilled Water Piping – Indoor	All	FG1	1-1/2"	Type A
Refrigerant Piping & Condensate Drain Pans	All	E1	½"	Type A
Steam & Condensate Return Piping - Indoor	Up to 1" 1-1/4" to 2" 2-1/2" to 4" Over 4"	FG1	1" 1-1/2" 2" 2-1/2"	Type A
Engine Exhaust and Site Fabricated Breaching	All	C1	2"	
Roof Drains	All	FG1	1"	
Hot Water Pumps		FG5	2"	
Heat Exchangers		FG5	2"	
Hot Water Heating Air Separators		FG5	2"	
Flash Tanks		FG5	2"	
Condensate Return Pump Receivers		FG5	2"	
Chilled Water Generators & Pumps		FG5	1"	
Chilled Water Expansion Tanks		FG5	1"	
Ground Storage Tank		F2	See plans	
DI Water	6" and Less 8" and More	FG1 FG1	1" 1 ½"	Type D Type D

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PART 4 - EQUIPMENT INSULATION DESIGN AND MINIMUM PRODUCT REQUIREMENTS

4.1 Equipment Insulation Requirements

A. Purpose

1. Provide insulation for energy conservation, personnel protection, condensation control, freeze protection, noise control, and fire protection.

B. Design insulation systems based on the following guidelines


1. Governing Code requirements
2. SMACNA Guidelines
3. ASHRAE Fundamentals Handbook – Insulation for Mechanical Systems
4. ASHRAE Energy Standards 90.1 and 189.1
5. LEED Requirements
6. Mechanical Insulation Design Guide by the National Mechanical Insulation Committee.
7. Thermal values to prevent condensation.
8. NFPA requirements
9. Appropriate vapor and water barriers.

C. Systems requiring insulation, but not limited to are:

1. Pumps
2. Thermal vessels
3. Valves: Manual, Control, and PRV (HPS, MPS, LPS, HW, CW, DHW)
4. Piping (HPS, MPS, LPS, HW, CW, DHW)
5. Appurtenances (HPS, MPS, LPS, HW, CW, DHW)

D. General Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
3. 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.
4. Keep insulation materials dry during application and finishing.
5. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
6. Install insulation with least number of joints practical.
7. Cut insulation in a manner to avoid compressing insulation more than 75 percent of

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its nominal thickness.

8. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
9. Repair damaged insulation facings by applying same facing material over damaged areas.
10. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

4.2 Preformed Thermal Jackets Product Requirements

A. Manufacturers:

1. ThermaXX LLC
2. Insultech
3. Approved equal.

B. Insulation


1. For Most Box Type Jackets:
 - a. High-temperature insulation blanket formed of silica Aerogel and reinforced with a non-woven, glass-fiber batting.
 - b. Insulation must be hydrophobic
 - c. Estimation of Maximum Use Temperature 1200°F (650°C)
2. For Most Non Box Type Jackets:
 - a. Glass mat, type E needled fiber. ¼", ½" @ 9 LB/CF & 1" @ 11.3 LB/CF. Maximum Use Temperature 1200°F (650°C)
 - b. Fiberglass mat with no chemical binders, type HP5 needled fiber. 1" @ 5 LB/CF. Maximum Use Temperature 1000°F (538°C)
3. All insulation materials shall be Non-Asbestos

C. Jacket Material Dry Locations:


1. Hot Side
 - a. Silicone Fiberglass Composite Jacketing, 17 oz/sq. yd. minimum
 - b. Estimation of Maximum Use Temperature 450°F (232°C)
2. Cold Side
 - a. Silicone Fiberglass Composite Jacketing, 17 oz/sq. yd. minimum
 - b. Estimation of Maximum Use Temperature 450°F (232°C)
 - c. Silicone Cloth 17oz./sq. yd minimum
 - d. Estimation of maximum use temperature 480F/249C

D. Jacket Material Wet Locations:

1. Hot Side

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- a. PTFE – LFP 2110 13.5 oz/sq. yd. minimum
 - b. Estimation of Maximum Use Temperature 600°F (315°C)
2. Cold Side
 - a. PTFE - LFP 2110 13.5 oz/sq. yd. minimum
 - b. Estimation of Maximum Use Temperature 600°F (315°C)
- E. Thread:
 - a. Kevlar
 - b. Begins to decompose at about 800 degrees (426 degrees C). Does not melt
 - c. Diameter- .0114 inches Break Point – 35LBS
- F. Construction:
 1. Sewn with lock stitch at a minimum of 4 to 6 stitches per inch. Jackets shall be sewn using specified thread in section 1.3D. The thread must be able to withstand the skin temperatures without degradation.
 2. Hog rings, staples and wire are not acceptable methods of closure.
 3. No raw cut jacket edges shall be exposed.
 4. Jackets shall be fastened using hook and loop (Velcro) straps and 1” Slide Buckles or D-rings.
 5. Provide a permanently attached Laser Etched Anodized Aluminum nameplate (2” x 3.5”) on each jacket to identify its location and item number. A record for each location (refer to Section 3.4) shall be maintained containing the following information:
 - a. Item Number
 - b. Location Information
 - c. Application Type
 - d. Operating Pressure
 - e. Component Type
 - f. Component Size
 - g. Jacket Min Max Temp
 - h. Insulation Thickness
 - i. Jacket material Hot Side
 - j. Jacket material Cold Side
 - k. Pre Photo & Post Photos
 - l. Pattern
 6. The insulation shall be designed to minimize the convection current in the space between the hot metal surface and the inner layer of insulation.
 7. All jacket pieces which match mating seams must include an extended 2” flap constructed from the exterior fabric and shall be secured using hook & loop closure (i.e. Velcro TM) parallel to the seam.
 8. Insulation must be sewn as integral part of the jacket to prevent shifting of the insulation. Insulation pins are NOT an allowable method of preventing the

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insulation from shifting and shall NOT be used.

9. Steam Trap Jackets must be constructed in a box shape for removal and replacement inspection ease.

4.3 Jacket Performance and Insulation Thickness

- A. Insulation thickness: As required for Touch Temperature
Exterior of all jacket < 120^F


4.4 Insulation Materials

- A. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- B. 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.
- C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

PART 5 - PIPE INSULATION FOR UTILITY SYSTEMS, MANHOLES, AND TUNNELS

5.1 Pipe Insulation

- A. Purpose
 1. Provide insulation for energy conservation, personnel protection, condensation control, freeze protection, noise control, and fire protection.
- B. Design insulation systems based on the following guidelines
 1. Governing Code requirements
 2. SMACNA Guidelines
 3. ASHRAE Fundamentals Handbook – Insulation for Mechanical Systems
 4. ASHRAE Energy Standards 90.1 and 189.1
 5. LEED Requirements
 6. Mechanical Insulation Design Guide by the National Mechanical Insulation Committee.
 7. Thermal values to prevent condensation.
 8. NFPA requirements
 9. Appropriate vapor and water barriers.


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C. Systems requiring insulation, but not limited to are:

1. Chilled water piping
2. HVAC hot water piping
3. Steam supply piping
4. Steam condensate piping
5. Domestic cold and hot water piping
6. Tempered water systems
7. Piping exposed to freezing
8. Roof drains and horizontal rainwater
9. Cold condensate floor drains and horizontal extensions.


D. Installation Requirements for Piping, Fittings, Valves, Strainers, Flanges, and Unions:

1. Provide heat trace for piping exposed to freeze conditions, heat trace shall be alarmed to BMS for failure of heat trace circuit.
2. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
3. 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.
4. 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.
5. 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.
6. 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.
7. Insulate flanges and unions using a section of oversized preformed pipe insulation.

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Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

8. 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.
 9. 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.
 10. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- E. 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.
- F. Install removable insulation covers. 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. Insulation jackets are preferred, however 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.
- G. Labeling and flow arrows complying with the Mechanical Identification requirements shall be applied to the exterior surface of insulation systems.
- H. Insulation shall be continuous through wall and ceiling openings.
- I. At location of pipe supports and hangers, there shall be a rigid thermal break to prevent the compression of insulation. Rigid thermal break shall be of sufficient thermal

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resistance to prevent internal and external condensation.

- J. At locations such as valves, and where equipment must be accessed, insulation shall be removable and be replaceable without compromising the integrity of the insulation and vapor barrier system.
- K. Design insulation system with appropriate vapor barriers to prevent moisture from entering, or becoming trapped within the insulation system.
- L. Apply insulation after systems have been tested and approved.
- M. Insulation for fittings and valves shall be pre-molded. Insulating wrap material is prohibited.
- N. Provide insulation stand-offs, for valve handles and similar devices.
- O. Provide non-corrosive insulation protection shields at locations of hangers, and supports
- P. Chilled water piping shall require vapor barriers.
- Q. Insulation system shall require wicking system to remove condensed water on the surface of piping outside of insulation system.
- R. Systems that require access and or service must be insulated with removable insulation systems.
- S. Special insulation systems shall be selected in areas of abuse, foot traffic, etc.
- T. General
 - 1. Installation Notes
 - a. General: Install insulation material with smooth and even surfaces. Unless otherwise specified, install insulation materials, accessories, and finishes in accordance with the manufacturer's published recommendations. All components of the piping systems shall be insulated including valves, strainers, and all other components.
 - b. Fire Precaution: Care shall be exercised by the Contractor that no cutting, welding, or open flames are permitted in the areas where flammable mastics or other materials are used. The precaution period shall extend until the material has cured sufficiently so that no further fire hazard exists.
 - c. Insulation Release: Before insulation is applied to any piping or equipment, the Contractor shall obtain from the Designers a written release stating that the item is ready for insulation.
 - d. Manufacturer's Recommendations: All materials specified herein shall be installed in full accordance with the manufacturer's recommendations for the best performance and durability of his product, notwithstanding any requirements or omissions herein with respect to preparation of equipment before insulating or method of application.
 - e. Expansion Joints In Insulation: Where necessary, the Contractor shall furnish suitable expansion joints in the insulation to prevent cracking or wrinkling due to expansion and contraction of the surface being insulated.
 - f. Surface Condition: Do not apply insulation materials until all surfaces to be covered are clean and dry, all foreign materials, such as rust, scale, and dirt

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have been removed, and surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish.


- g. **Moisture and Vapor Seal:** Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces for which a vapor seal is specified.
- h. **Asbestos Containing Material:** No Contractor, Subcontractor, or Supplier shall furnish any asbestos containing material.

2. Piping Insulation Installation

- a. All sectional pipe insulation shall be applied with staggered girth joints tightly butted together as recommended by the insulation manufacturer. Each section of insulation is to be held in place with separate loops of 16 gauge annealed stainless steel wire placed not more than 12 inches on center.
- b. Insulation shall not be applied to any flanged, machined, or welded surfaces until they have passed all field tests, including hydrostatic, and have been released for insulation.
- c. **Insulation of Valves:**
 - 1) For all valves (no matter what size) in all locations, the blanket shall cover the body and shall not include the valve bonnet.
 - 2) In all insulated lines, except for those items insulated with blankets, the valve bodies, fittings, and flanges shall be insulated with the same material and the same thickness as the pipe insulation using mitered pipe insulation and/or block insulation securely cemented together. All flange insulation shall be the removable type, but not the replaceable type.
- d. Do not insulate steam traps and unions upstream and downstream of steam traps.
- e. **Gaps and Terminations:** Neatly terminate all insulation at each end of unions and at other points where required and seal. Fill gaps occurring at hangers with insulating cement and finish flush with the adjoining pipe insulation as specified for fittings.
- f. **Wall and Floor Openings:** Install insulation and coating of jackets continuous through wall and floor openings.
- g. Butt pipe insulation against pipe hanger insulation inserts. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inch wide vapor barrier tape or band.

3. Equipment Insulation Installation

- a. **Insulation Supporting Clips and Other Components:** Where insulating clips, supports, angles, studs, washers, etc., are not furnished with the equipment, the Contractor shall furnish and install them. The necessity for location of, quantity, and manner of application shall be as approved by the Engineer.
- b. **Insulation Over Irregular Surfaces:** All irregular surfaces, heads, outlets,

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nozzles, and fittings shall be insulated with the same material and the same thickness as specified for the tank or equipment of which they are a part. Where necessary, the designated insulation shall be applied in a plastic form and trowelled to a smooth finish.

- c. Removable Manhole and Handhole Covers: Removable covers shall be so arranged with insulation stop rings, tapered insulation, etc., that they can readily be removed without disturbing the insulation or its finish. Such removable sections need not be of the type which after having been removed can be installed.
- d. Corner Trim for Insulation Finish: Where necessary, the Contractor shall furnish and install metal corner bead and expansion base screen, secured to the poultry wire netting, to obtain a uniform thickness and workmanlike, quality installation.

U. Steam and Condensate

1. Tunnels and Buildings

- a. Shall be fiberglass, preformed insulation in compliance with ASTM C 547, Class 1, rigid insulation. Thermal conductivity according to ASTM C 335 shall have a minimum of 0.24 BTU-in/hr-sq. ft. deg F at 100 deg F mean temperature and below 0.29 -in/hr-sq. ft. deg F at 200 deg F mean temperature. Insulation shall conform to ASTM C 795. Insulation shall be rated for continuous temperatures to 850 deg F.


b. Insulation Thickness

1) HPS and HPR

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
3/4" and below	1-1/2"
1" to 1-1/2"	2"
2" to 2-1/2"	2-1/2"
3" to 4"	3"
6"	3-1/2"
8" to 10"	4"
12" to 18"	4-1/2"

2) MPS and MPR

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
3/4" and below	1"
1" to 1-1/2"	1-1/2"

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2" to 2-1/2"	2"
3" to 4"	2-1/2"
6" to 10"	3"

3) LPS and LPR

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
2" and below	1"
2-1/2" to 4"	1-1/2"
6" to 8"	2"
10" to 18"	2-1/2"


4) PC

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
6" and below	1"
8" to 18"	1-1/2"

- c. Acceptable Manufacturers: Johns-Mansville, Owens Corning, or Knauf.
- d. Insulation jacket shall be PVC jacket as follows:
 - 1) Covering shall be produced from white, glossy, high impact, polyvinyl chloride compound such as Johns Manville Zeston® 300 Series PVC or approved equal.
 - 2) Thickness shall be 20 mil. Provide gloss finish.
 - 3) Color to be white to maintain the flame spread and smoke developed rating.
- e. Operating temperature shall be rated to 150 degrees F. Flame spread of 25 or less. Smoke developed rating of 50 or less.

2. Manholes

- a. Insulation shall be molded sections of inorganic silicate (calcium or sodium) or expanded perlite. The insulation shall conform to ASTM C533 - Type 1, ASTM C795, and ASTM E84 (0 Flame, 0 Smoke). The calcium silicate shall have a maximum service temperature of 1200 deg. F, a density of 14 LB per cubic foot, and a thermal conductivity of 0.67 BTU-in/hr-sq. ft. deg F. at a

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mean temperature of 700 degrees F per ASTM C335. Linear shrinkage shall be less than 1%. The insulation shall be certified by the manufacturer not to accelerate stress corrosion of stainless steel pipe and shall conform to ASTM C795.

b. Insulation Thickness

1) HPS and HPR


Nominal Pipe Size (IN)	Insulation Thickness (minimum)
3/4" and below	1-1/2"
1" to 1-1/2"	2"
2" to 2-1/2"	2-1/2"
3" to 4"	3"
6"	3-1/2"
8" to 10"	4"
12" to 18"	4-1/2"

2) MPS and MPR

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
3/4" and below	1"
1" to 1-1/2"	1-1/2"
2" to 2-1/2"	2"
3" to 4"	2-1/2"
6" to 8"	3"
12" to 18"	3-1/2"

3) LPS and LPR

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
2" and below	1"
2-1/2" to 4"	1-1/2"
6" to 8"	2"
10" to 18"	2-1/2"

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4) PC

Nominal Pipe Size (IN)	Insulation Thickness (minimum)
6" and below	1"
8" to 18"	1-1/2"


c. Jacket

- 1) Insulation jacket shall be weatherproof aluminum. The jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 016 inch thick, fabricated with 3/16 inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service. All joints shall be made rain or drip proof. Longitudinal joints shall be located on the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water out of the joint shall have the inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.
- 2) The aluminum jacket shall be secured by aluminum straps 1/2 inch wide by 0.020 inch thick. The straps shall be placed on 12 inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.
- 3) Provide mastic for all insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied.

V. CHILLED WATER

1. Rigid Cellular Glass Insulation

- a. Insulation shall be 100 percent rigid cellular glass, totally inorganic, with no binder. Absorption of moisture shall be 0.2% or less per ASTM C 240. Water-vapor permeability shall be 0.0 perm-in per ASTM E 96. Average compressive strength shall be 90 psi ASTM C 165. Average density shall be 7.5 lb per cubic foot per ASTM C303.
- b. Maximum service temperature shall be 900 degrees F. Thermal conductivity shall be no greater than 0.28 Btu-in/hr-sq. Ft. - degree F at 50 degrees F per ASTM C 177 and ASTM C 518. The insulation shall conform to ASTM E 84 (5 Flame, 0 Smoke). Linear expansion shall be 3 inches per 100 linear feet at


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600 degrees F. Insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved side wall segments are preferred.

- c. Provide insulation from one of the following manufacturers and product trade names:
 - 1) Pittsburgh Corning FOAMGLAS
 - 2) 800 Presque Isle Drive Pittsburgh, PA 15239
 - 3) Phone Number: (800) 359-8433
- d. Pipe surfaces shall be clean and dry prior to insulating.
- e. Provide PITTSEAL 727 sealant to prevent water vapor entry. Provide PITTCOTE 300 coating to fill the surface cells. Ensure that all pipe surfaces are covered by insulation and that the insulation is sealed and coated so that no condensation takes place on the pipe surface.
- f. Insulation shall be temporarily held in place with stainless steel wire or fiber reinforced tape overlapped a minimum of 6 inches prior to the insulation finish being installed. The tape and/or wire may remain on the insulation beneath the insulation finish.
- g. Thickness shall be per manufacturer's recommendations. For tunnels and manholes where steam or condensate piping is present, ambient conditions shall be selected for 120 degrees F and 90 percent relative humidity.
- h. Insulation jacket shall be PVC jacket as follows:
 - 1) Covering shall be produced from white, glossy, high impact, polyvinyl chloride compound such as Johns Manville Zeston® 300 Series PVC or approved equal.
 - 2) Thickness shall be 20 mil. Provide gloss finish.
 - 3) Color to be white to maintain the flame spread and smoke developed rating.
 - 4) Operating temperature shall be rated to 150 degrees F. Flame spread of 25 or less. Smoke developed rating of 50 or less.

W. RE-USABLE BLANKETS FOR VALVES

- 1. Provide re-usable blankets for pressure regulating valves.
- 2. General
 - a. Insulating material shall be tailor-made removable/reusable blankets. The blankets shall be made with a high temperature fiberglass mat without the use of chemical binders and suitable for temperatures up to 1200 degrees F.
 - b. All blanket and covers shall be constructed and designed to permit a heat of no more than 92 Btu/sq. ft./hour and a surface temperature of not more than 135 degrees F. in still air at an ambient temperature of 80 degrees F. The minimum blanket insulation thicknesses shall be as follows:
 - 1) Operating Temperature of 130 to 300 degrees F: 1" thick

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- 2) Operating Temperature of 301 to 400 degrees F: 2" thick
 - 3) Operating Temperature of 401 to 500 degrees F: 3" thick
 - 4) Operating Temperature of 501 to 800 degrees F: 4" thick
 - 5) Operating Temperature of 801 to 1000 degrees F: 6" thick
- c. Single layer blanket construction may be used for metal temperatures up to 600 degrees F. For metal temperatures over 600 degrees F., double layer construction must be used. The joints for double construction between blankets of the inner layer and those of the outer layer shall be offset from one another.
 - d. The inner liner material for hot surface temperatures up to 500 degrees F. shall be silicone coated glass cloth, 32 ounce. For hot surface temperatures between 500 and 1000 degrees F., the blanket insulation material shall be enclosed on all sides with a knitted wire mesh. The knitted wire mesh shall be 304 stainless steel wire, 0.11" (11 mils) knitted into a tubular fabric using a mesh size of 60 density.
 - e. The exterior jacket material shall be silicone glass cloth 32 ounce.
 - f. All blankets shall be quilted at frequent intervals with quilting fasteners.
 - g. The blankets shall be made and designed to fit tightly around the outside diameters of the flanges and valves, leaving no gaps when laced. Each blanket shall be constructed with 16 gauge stainless steel wire draw strings that pass through hog rings and are spaced 3/4 inch apart. All mating edges of adjacent blankets shall be fitted with blanket hooks, spaced approximately 6 inches on centers or as required to provide securement for the stainless steel tie wire that are used to lace adjacent blankets together.
 - h. Where blankets are provided for valves, the cover shall cover the body but not the valve bonnet.