

PART 1 - GENERAL

These standards apply to the insulation of piping systems, air distribution systems, equipment, liquid storage vessels and accessories.

1.01 DESCRIPTION

A. Design Criteria:

1. All surfaces shall be insulated, which would reduce heat gain or loss, avoid undesirable condensation and/or reduce corrosion.
2. Fire and Smoke Requirements: Flame spread rating of 25 and developed smoke rating of 50 for all materials used in plenum areas. In non-plenum areas, smoke developed rating per local code requirements and NFPA maximum allowed.
3. Existing Insulation: Indicate removal, repair and/or replacement of damaged covering on existing equipment and piping.
4. As a minimum, the following systems and components shall be insulated:
 - a. Domestic Systems subject to 105 degrees F or greater and 55 degrees F and below: Cold water, hot water, tempered, and re-circulating piping; valves, storage tanks and appurtenances.
 - b. Rainwater: Rain leaders, overflow rain leaders, roof drain and overflow roof drain bodies. Insulation not required for underground, in utility tunnels, in crawl spaces, and in unexcavated areas.
 - c. Heating Systems 105 degrees F or greater: Steam, condensate, heating water, make-up water piping, boilers, tanks, valves, converters and pumps.
 - d. Services 55 degrees F or below: Chilled water, make up water and condensate drain piping, glycol systems, chillers, tanks, valves, pumps, brine systems, refrigerant systems, fuel systems, and other system fluids. Chilled water piping within air handlers (multiple coil branches) to be insulated. All insulation systems for these services shall be protected by a continuous vapor retarder system. Joint sealer shall contribute to this system. The sealant must be water vapor and liquid tight, and shall bond to the insulation. Sealant shall be applied completely to all insulation

sections of the system, including all seams, joints, ends, terminations, and penetrations to prevent vapor and condensation from penetrating the insulation system. Piping subject to significant contraction or cycling shall be adhered to the service piping (bore coat).

- e. Air Distribution System: Per Washington State Energy Code and as described below.
- f. Outdoor air ductwork and plenums.
- g. Exhaust air ductwork and plenums: Downstream of back-draft or motorized damper to exhaust louver.
- h. Supply air ductwork.
- i. Return air ductwork: Not within conditioned space, in enclosed ceiling space, in walls, in garage, or in crawl spaces, in concrete, or in the ground.
- j. All ductwork exposed outside building envelope.
- k. Steam and condensate vent piping shall be insulated for personal protection.
- l. Breeching, Stack, Induced Fan Housing and duct for existing Central Mechanical Plant or entire breeching system for new boiler plants, including flue gas return system.
- m. Equipment Connections: Insulate all risers, branches and connections to equipment.
- n. Do not insulate direct burial domestic cold water piping, condenser water piping (except to avoid undesirable condensation), over equipment data or ASME labels and sound lined ductwork unless code requires.
- o. Exposed Piping: Increase insulation thickness for all piping in outside tunnels or where exposed to outside temperatures.
- ~~o.p.~~ Jackets: Provide metal jackets with waterproof joints and seams on all outdoor insulated piping and ductwork. Seams to be located along the underside of piping and ductwork with all overlaps facing down to shed water. Seal all exterior piping and ductwork seams of jacketing. Provide metal or PVC jackets to protect insulation where subjected damage in the terminal or other buildings. F&I will provide direction as to which services will be jacketed with metal or PVC, depending on location. Piping Specialties Removable Covers: Thermaxx, Ayvaz, ProTherm,

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InsulationJacket: Aspen aerogels hydrophobic insulation materials with low thermal conductivity. Cryogel X201 for the applications between 0 °C and 200 °C and using Pyrogel XT between, 200 °C – 650 °C. Fiber glass fabric with silicon cover (80gr-100gr). Sewing of the fabrics is completed by Kevlar and stainless steel wires. Braided fiber glass ropes with high temperature resistance for tying points. Provide removable covers on all strainers, controllers, circuit setters, balance valves, combination valves, pump bodies, unions, and flanged removable assemblies requiring access for maintenance, repair or cleaning. Identification: See General Provisions “Mechanical Identification.”

1. Insulation

Tables:

PIPING INSULATION THICKNESS IN INCHES FOR PIPE SIZES

	Temperature Range °F	Less than 1"	1"to1-1/2"	1-1/2"to 4"	4" to 8"	8"& up
Water Systems						
Hot water, Tempered & Re-circulating	100 to 140	1"	1"	1-1/2"	1-1/2"	1-1/2"
	Conductivity .21-.28					
	141 to 200	1-1/2"	1-1/2"	2"	2"	2"
Cold Water, Non- potable, Roof Drains, Rainleaders	----	1/2"	1/2"	1/2"	1/2"	1/2"
Conductivity Btu.in/(h.ft².F°) *						
Heating Systems						
Steam, Condensate	Above 350	4-1/2"	5"	5"	5"	5"
	251 – 350	3"	4"	4-1/2"	4-1/2"	4-1/2"
	250 and less	2-1/2"	2-1/2"	2-1/2"	3"	3"
Heating Water	105 to 200	1-1/2"	1-1/2"	2"	2"	2"
Cooling Systems						
Chilled Water, Condensate Drain	40 to 55	1/2"	1/2"	1"	1"	1"
Glycol Chilled Water (Pre- Conditioned Air System)	0 to 39	1"	1-1/2"	1-1/2"	1-1/2"	1-1/2"

- a. * For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:
- $$T = r \left\{ \left(1 + \frac{t/r}{K_A} - 1 \right) \right\}$$
- where:
 T = minimum insulation thickness,
 r = actual outside radius of pipe,
 t = insulation thickness listed in the table for applicable fluid temperature and pipe size,
 K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu × in/h × ft² × °F)
and
 k = the upper value of the conductivity range listed in the table for the applicable fluid temperature.
For direct-buried heating and hot water system piping, reduction of these thicknesses by 1/2 inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch

DUCT INSULATION R-VALUES

Duct Type	Duct Location	R-Value
Supply, Return	Not within conditioned space	R-7
All	Outside building envelope	R-11
Supply	Within conditioned space	R-3.3
Outside, Exhaust	Within conditioned space	R-7

INSULATION TYPE APPLICATION

Ductwork Application:	Material
Not within conditioned space - rectangular	Mineral-fiber rigid board
Not within conditioned space - round	Mineral-fiber blanket
Within conditioned space	Mineral-fiber blanket
Piping Application:	Material
Domestic cold, hot, tempered, non-potable and re-circulating	Glass-fiber, Closed-cell phenolic foam
Condensate drain	Glass-fiber, Flexible elastomeric or polyolefin
Chilled water	Glass Fiber, Flexible elastomeric, phenolic foam, products with K factor less than 20 such as Aspen Pyrogel XT-E DS (with engineer calc'd thickness)
Glycol Chilled Water	Cellular Glass
Heating water	Glass Fiber, Flexible elastomeric
High and Medium Pressure Steam and Condensate	Calcium silicate, Silica aerogel
Low Pressure Steam and Condensate	Silica aerogel Glass Fiber, Calcium silicate

Insulation shall meet or exceed Washington State Energy Code.

Exhaust air ductwork shall be insulated within conditioned space where subjected to outside air conditions.

PART 2 – PRODUCTS

2.01 INSULATION

- A. Manufacturers: Aerogel, Johns-Manville, Owens-Corning, Knauf GmbH, Pittsburgh Corning, Armaflex, or approved equal.
- B. Pipe Insulation: Insulation thickness is based on insulation having a thermal resistance of 4.0 to 4.6 per inch of thickness at a mean temperature of 75 F. Insulation thickness shall be increased or decreased for materials having R values less than 4.0 per inch or greater than 4.6 per inch.
- C. Preformed Glass Fiber Pipe Insulation: Comply with ASTM C547, Type I, with factory-applied, all-purpose, vapor-retarder jacket. Provide sealant as required to develop a vapor retardant system.
- D. Calcium Silicate Insulation:
 - 1. Piping: Preformed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - 2. Ductwork: Flat, curved, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
- E. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible. For block insulation, comply with ASTM C 552, Type I. For special shaped insulation, comply with ASTM C 552 Type II and Type III. For board insulation, comply with ASTM C 552, Type IV. Provide sealant on all sections as required to develop a vapor retardant system. Sealant shall be applied completely to all insulation sections of the system, including all seams, joints, flanges, drains, vents, instrument connections, gauge taps, ends, terminations, and penetrations to prevent vapor and condensation from penetrating the insulation system. Piping subject to significant expansion, contraction or cycling shall be adhered to the service piping (bore coat). Insulate

tanks and other equipment with smooth surfaces with cellular or foam glass. As an option, valves, pump bodies, strainers, flanges, flex connectors, control valves, and other devices to be insulated with flexible elastomeric insulation, vapor retarder tied to cellular/foam glass, and removable covers added.

F. Closed-Cell Phenolic-Foam Insulation:

1. Piping:

- a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1. Provide sealant as required to develop a vapor retardant system.
- b. Block: Rigid, expanded, closed cell structure. Comply with ASTM C 1126, Type II, Grade 1. Provide sealant as required to develop a vapor retardant system. Sealant shall be applied completely to all insulation sections of the system, including all seams, joints, ends, terminations, and penetrations to prevent vapor and condensation from penetrating the insulation system. Piping subject to significant contraction or cycling shall be adhered to the service piping (bore coat). Insulate tanks and other equipment with smooth surfaces with phenolic insulation. As an option, valves, pump bodies, strainers, flanges, flex connectors, control valves, and other devices to be insulated with flexible elastomeric insulation, vapor retarder tied to cellular/foam glass, and removable covers added.

G. Flexible Elastomeric Thermal Insulation:

1. Closed-cell, sponge or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Provide sealant as required to develop a vapor retardant system.
2. Jacket from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

H. Polyolefin Insulation: Unicellular polyethylene thermal plastic, preformed pipe insulation. Comply with ASTM C 534, Type I, except for density. Provide sealant as required to develop a vapor retardant system.

I. Flexible Aerogel Insulation: Amorphous silica-based aerogel cast into a fiber reinforcement. The fiber reinforcement may consist of a batt, a needled felt blanket, or other configurations of fibers. The fibers themselves may be inorganic, such as glass fibers, or organic, such as polyethylene. The flexible

aerogel insulation may contain hydrophobic agents and may also contain opacifiers.

1. Comply with ASTM C1728 Type III Grade 2 Category A.
2. 'K' factor: ASTM C177, 0.16 Btu-in/Hr-sq. ft.-degree F at 212 degrees F.
3. Maximum service temperature: 1,200 degrees F.
4. Density 11 lb./cu. ft.
5. ASTM E 84 Flame spread 0, Smoke developed 0.

J. MICROPOROUS INSULATION

1. Composite material in the form of compacted powder or fibers with an average interconnecting pore size comparable to or below the mean free path of air molecules at standard atmospheric pressure. Microporous insulation may contain opacifiers to reduce the amount of radiant heat transmitted. The resulting blend of materials and pore structure produces a thermal insulation with extremely low thermal conductivity across a broad temperature range. The Microporous core material is completely inorganic making it non-combustible.

a. Comply with ASTM C1676 Type III Grade 2 Hydrophobic.

'b. Thermal Conductivity 'K' factor: ASTM C177, 0.153 Btu-in/hr-sq. ft.-degree F at 212 degrees F.

c. Maximum service temperature: 1470 degrees F.

d. Density: 0.0116-0.0126 lb./cu. in.

Non-combustible

K. Covers:

1. Prefabricated Thermal Insulating Fitting Covers: UL 25/50 rating, non-combustible per ASTM E 136, 20 mil minimum thickness. Comply with ASTM C 450 for dimensions used in performing insulation to cover valves, elbows, tees and flanges. Provide sealant as required to develop a vapor retardant system.

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2. Piping Specialties Removable Covers: Flexible fiberglass fabric, impregnated with silicone or teflon, minimum weight of material to be 17 oz/sq yard, plain weave, minimum thickness of .015", tensile strength of 250 lb/in or FTMS 191A. Temperature resistance of 450 deg F, rated for both outdoor and indoor use and UV resistant. Fill with fiberglass minimum of 1 lb/cubic ft density, same thickness as adjacent insulation and comply with current Washington State Energy Code minimum. Comply with ASTM C1695.
 - a. Provide copper or stainless eyehooks and wire, 14 gauge minimum for eyehooks and 20 gauge minimum wire for lacing the blanket.
 - b. Removal and re-installation of system shall not require any special hand tools.
 - c. Removable covers to overlap adjacent insulation.
 - d. Manufacturers to be Auburn Manufacturing, Inc. AMI TUF series, GLT 725 series, Shannon Insultech, or approved equal.
 - L. Jackets:
 1. Laminated: All purpose, Kraft paper, aluminum foil NFPA 90A approved and 0.02 permeability, exterior layer kraft paper.
 2. Canvas: 4 oz. factory applied, 6 oz. field applied.
 3. Metal: (0.016-inch aluminum) or (0.010-inch stainless steel), ASTM B209, stucco embossed finish if not required to be painted. If specified to be painted, finish shall be smooth and prepped for painting. Joints to have 2" overlaps. Fittings to be factory die shaped with factory liner. Bands to be minimum 3/8" wide, minimum .015" thick aluminum or minimum .010" thick stainless steel. All exterior (exposed to weather) insulation shall be protected with metal jacketing.
 4. PVC: ASTM D1784 for pipe, sheet material for ducts. One piece molded type fitting covers and sheet material in off-white color, 20 mil thick minimum, brush on welding adhesive and pressure sensitive color matching vinyl tape. ASTM E96, .002 perm-inches moisture vapor transmission for system. All ramp, mechanical rooms, bagwell, interstitial, tunnel, utilidors, and other areas exposed to damage shall be covered with PVC jacketing. Insulation exterior but protected from weather shall be protected with PVC jacketing.

- 5. Asphaltic: Fibrated solvent asphalt waterproof. For below grade applications only.
- M. Mineral-Fiber Rigid Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
- N. Mineral-Fiber Blanket Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C553, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, or aluminum foil. Vinyl film not allowed.
- O. Duct Liner:
See Section 233000 "Air Distribution System."

END OF SECTION