**PART 1 – GENERAL**

* 1. **SUMMARY**
1. Section Includes:
	1. Condensate drain piping from air conditioning equipment.
	2. Vacuum and condensate pump discharge lines over 50 feet in length.
	3. High and low temperature equipment.
	4. Heating hot water supply and return piping.
	5. Chilled water supply and return piping.
	6. Refrigerant piping.
	7. Supply and return air ducts for heating and cooling systems air ducts.
2. Related Requirements:
	1. Division 01: General Requirements.
	2. Section 23 05 00: Common Work Results for HVAC.
	3. Section 23 05 13: Basic HVAC Materials and Methods.
	4. Section 23 05 53: Mechanical Identification.
	5. Section 23 20 13: Above Ground HVAC Piping.
	6. Section 23 20 16: Underground HVAC Piping.
	7. Section 23 30 00: Air Distribution.
	8. Section 23 50 00: Central Heating Equipment.
	9. Section 23 80 00: Heating, Ventilating and Air Conditioning Equipment.
	10. **REFERENCES**
3. American Society for Testing and Materials International (ASTM):
4. ASTM C167 - Standard Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.
5. ASTM C209 - Standard Test Methods for Cellulosic Fiber Insulating Board.
6. ASTM C302 - Standard Test Method for Density and Dimensions of Preformed Pipe-Covering-Type Thermal Insulation.
7. ASTM C411 - Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
8. ASTM C518 - [Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus](https://www.astm.org/Standards/C518.htm).
9. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
10. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
11. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
12. ASTM D5116 - Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products.
13. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
14. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
15. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
16. ASTM G22 - Standard Practice for Determining Resistance of Plastics to Bacteria.
17. Underwriters Laboratories Inc.:
18. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.
19. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
20. National Fire Protection Association:
21. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
2. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
	1. **SUBMITTALS**
3. Submit in accordance with Division 01 and Section 23 05 00: Common Work Results for HVAC.
4. Complete material list of items to be furnished and installed under this Section.
5. Manufacturer's specifications and other data required demonstrating compliance with the specified requirements.
6. Shop Drawings, catalog cuts and manufacturer's data indicating insulation, jacketing, adhesives, and coating. Insulating materials shall be certified by manufacturer to comply with the California quality standards for insulating materials.
7. Display sample cutaway sections.
8. Manufacturer's recommended method of installation procedures, which will become part of this Section.
	1. **QUALITY ASSURANCE**
9. Qualifications of Manufacturer and Installer, Materials, Fabrication, Execution, and Standard of Quality: Comply with provisions stated under Section 23 05 00: Common Work Results for HVAC and Section 23 05 13: Basic HVAC Materials and Methods.
10. Test Ratings:
11. Comply with provisions stated under Section 23 05 00 and 23 05 13 with emphasis on ASTM E84, NFPA 255, or UL 723. ASTM C167, ASTM C302, UL label or listing of satisfactory test results from the National Institute of Standards and Technology, or a satisfactory certified test report from an acceptable testing laboratory. Approval by the State Fire Marshal is required.
12. Furnish labels, legibly printed with the name of the manufacturer or listings indicate that fire hazard ratings do not exceed those specified for materials proposed for installation. Flame spread index of not more than 25 and smoke developed rating not exceeding 50.
13. Tests shall be performed on each item individually when insulation, vapor barrier covering, wrapping materials, or adhesives are installed separately at the Project site.
14. Test insulation, vapor barrier covering, wrapping materials and adhesives as an assembly when they are factory composite systems.
15. Regulatory Requirements: Insulation furnished and installed under this Section shall conform to the requirements of the California Building Code Parts 4, Mechanical Code, Part 5, Plumbing Code and Part 6, Energy Code.
16. All chemically based products such as sealers, primers, fillers, adhesives, etc. shall meet the California air quality regulations.
	1. **PRODUCT HANDLING**
17. Protection, Replacement, Delivery and Storage: Comply with provisions stated under Sections 23 05 00: Common Work Results for HVAC and 23 05 13: Basic HVAC Materials and Methods.

**PART 2 – PRODUCTS**

* 1. **MATERIALS**
1. General:
2. Piping insulating material shall be fire resistant, non-corrosive, shall not break, settle, sag, pack or disintegrate under vibration, nor absorb more than 1 percent moisture by weight.
3. Piping insulating material shall be furnished with thickness indicated in Table 1, unless otherwise noted on the drawings, and shall furnish thermal resistance in the range of R-4.0 to 4.6 in accordance with inch at 75 degrees F. For any other value of R, insulation thickness shall be calculated accordingly and submitted for review.
4. Asbestos in any quantity in insulating material is not permitted.
5. Provide insulation materials, adhesives, coatings, sealants, fitting covers, and other accessories with a fire hazard rating not to exceed 25 for flame spread, 25 for fuel contributed and 50 for smoke developed, except for materials listed as follows:
	1. Nylon anchors for installing insulation to ducts or equipment.
	2. Treated wood blocks.
6. Flame-proofing treatments subject to moisture damage are not permitted.

TABLE 1 - MINIMUM PIPING INSULATION THICKNESS (1)

Insulation Thickness Required (in inches)

Space Heating Systems (Steam, Steam Condensate and Hot Water)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Piping System Type** | **Temp. Range** **(degrees F)** | **Run-outs up to 2** (2) | **1 and less** | **1.25 to 2** | **2.5 to 4** | **5 to 6** | **8 and larger** |
| Hi Pres Temp | Above 350 | 1.5 | 2.5 | 2.5 | 3.0 | 3.5 | 3.5 |
| Med Pres Temp | 251 to 305 | 1.5 | 2.0 | 2.5 | 2.5 | 3.5 | 3.5 |
| Low Pres Temp | 201 to 250 | 1.0 | 1.5 | 1.5 | 2.0 | 2.0 | 3.5 |
| Hot Water | Up to 200 | 0.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Steam Cond. | - | 0.5 | 1.0 | 1.0 | 1.0 | 1.5 | 1.5 |
| Service Water Heating Systems (recirculating, piping supply and return) |
| Hot Water | Up to 180 | 0.5 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| Space Cooling Systems (Chilled water, Brine and Refrigerant) |
| Chilled Water | 40-60 | 0.5 | 0.5 | 0.75 | 1.0 | 1.0 | 1.0 |
| Refrigerant/Brine | Below 40 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |
| Condensate Drain | ½-inch Minimum insulation thickness. | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| From Air Conditioning Equipment: | Insulate condensate drain lines within building, in room, inside walls and above ceilings. | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

NOTES:

* + - 1. For Underground HVAC Piping refer to section 23 20 16 Underground HVAC Piping.
			2. For piping exposed to ambient temperatures, increase thickness by 0.5 inch.
			3. Run-outs to individual terminal units, not exceeding 12 feet in length.
1. Lagging Adhesives: Shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Insulation finished with canvas shall be provided with laps adhered in accordance to manufacturer’s recommendation. A finish coat of same material shall be applied to entire outer surface of lagging cloth at coverage specified by manufacturer.
2. Canvas Jackets: Furnish 6 ounce in accordance with square foot minimum, 48 by 48 thread count canvas jacketing.
3. Insulation Jackets:
4. Exterior insulation exposed to weather shall be weatherproofed with Childers aluminum jacketing as basis of design, or Pabco, RPR, or equal. Jacketing shall be manufactured from 1100, 3105 or 5010 aluminum alloy with 3/16-inch corrugations. Smooth or embossed jackets may be permitted in special situations to match an existing installation. Jacketing shall be furnished with an integrally bonded moisture barrier over entire surface in contact with insulation. A minimum thickness of 0.016 aluminum jacketing is to be provided on ducts and piping. A minimum thickness of 0.020 shall be provided on tanks, equipment, and heat exchangers.
5. Insulated elbows, of 90 degrees and 45 degrees, with a nominal iron pipe size of ½-inch to 8-inch shall be provided with Childers aluminum Ell-Jacs insulation covers as basis of design, or Pabco, RPR, or equal, manufactured from 1100 aluminum alloy of 0.024-inch thickness. Insulated elbows with a nominal pipe size of 10 inches to 18 inches shall be provided with Childers 4-piece aluminum Ell-Jacs as basis of design, or Pabco, RPR, or equal.
6. Tees, Flanges, and Valve Insulation in Conjunction with Aluminum Jacketing: Furnish Childers Aluminum Special Fabrications Insulation Covers as manufactured by Childers Products Company, Pabco, RPR, or equal.
7. Adhesives: Adhesives shall be water based, UL Classified, meet the requirements of NFPA 90A and NFPA 90B, have been tested according to relevant ASTM requirements, and be acceptable to the State Fire Marshal. Name, type and method of installation shall be submitted for review.
8. Valve and Fitting Cover: When installed in conjunction with PVC jacketing, furnish Zeston 25/50 rated polyvinyl chloride fitting covers as manufactured by Johns Manville or equal.
	1. **SPACE HEATING PIPING SYSTEM**
9. General: Insulate steam, steam condensate return, and hot water space heating supply and return, including valves, strainers and fittings with insulation thickness as indicated on Table 1.
10. Materials:
11. Classes of Insulation:
	1. Class A: Calcium silicate molded pipe insulation, suitable for service temperature up to 1200 degrees F, ASTM C533; Johns Manville Thermo-12, Owens-Corning Kaylo-10, or equal. Fittings: diatomaceous silica thermal insulating cement.
	2. Class B: Glass fiber molded pipe insulation suitable for service temperatures up to 850 degrees F. Pipe insulation shall be one piece, preformed, and provide a minimum R factor of 4.0 at 75 degrees F mean temperature. Insulation shall be faced with all-purpose fire-retardant vapor barrier jacket. Pipe insulation shall be Johns Manville Micro-Lok, CertainTeed Snap-On, Owens Corning ASJ/SSL.
	3. Class C: Flexible open-cell melamine (foam insulation) suitable for service temperature -150 degrees F to 400 degrees F. Thermal conductivity at 75 degrees F, K = 0.26. Pipe insulation, one-piece pre-formed, laminated to heavy non-reinforced PVC jacket, with locking track, factory installed to jacket, to snap insulation and jacket onto pipe. Similar to Thermazip insulating or Techlite Melamine Form Insulation System as manufactured by Accessible Products Co., or equal. Installation shall comply with manufacturers recommendations.
	4. Class D: Mineral fiber pipe insulation suitable for service temperatures up to 1,200 degrees F. Pipe insulation shall be one-piece, preformed up to 3 inches thickness, and provide a minimum R factor of 4.0 at 75 degrees F mean temperature. Insulation shall be faced with all-purpose fire-retardant vapor barrier jacket. Pipe insulation shall be 8 pounds in accordance with cubic foot density by Industrial Insulation of Texas Inc., Delta Snap Wrap, Bradford Enercon Enerok, Lapinus 1200, or equal.
12. Locations and Class of Insulation Required:

TABLE 2 – LOCATIONS AND CLASS OF INSULATION REQUIRED

|  |  |
| --- | --- |
| LOCATION  | CLASS OF INSULATION |
| Boiler and MechanicalEquipment Room  | A, B, C, or D |
| All Other Locations | A, B, C, or D |

1. Fittings on indoor piping shall be covered with flush, hand-wrapped Class A, B, C, or D insulation, to match the adjoining pipe insulation and covered with polyvinyl chloride fitting covers: Zeston 2000 25/50 by Johns Manville, or equal.
2. Adhesive: Fibrous Adhesive to bond calcium silicate to itself and non-porous surfaces.
	1. **COOLING PIPING SYSTEM INSULATION**
3. General: Insulate chilled water supply and return piping and refrigerant piping.
4. Materials:
5. Classes of Insulation:
	1. Class A: Expanded polystyrene pipe insulation, self-extinguishing type, either molded or extruded; Dow Chemical Co. STYROFOAM FR, California Zonolite Co. Dyfoam, or Koppers Insulfoam.
	2. Class B: Glass fiber molded pipe insulation ASTM C547. Pipe insulation shall be one piece, preformed, and provide a minimum R factor of 4 at 75 degrees F mean temperature. Insulation shall be faced with all-purpose fire-retardant vapor barrier jacket. Pipe insulation shall be Johns Manville Micro-Lok, CertainTeed Snap-On, or Owens Corning ASJ/SSL II.
	3. Class C: Expanded (foamed) urethane (polyurethane) or polyisocyanurate pipe insulation of self-extinguishing type molded or fabricated, UpJohn Co. CFR Division, Armstrong Armalok or Expando-foam, or Owens-Corning Urethane.
	4. Class D: Foamed plastic pipe insulation, self-extinguishing type, ASTM C534 Type 1 - tubular. Pipe insulation shall be one-piece preformed, flexible tubing type and provide a maximum K factor of 0.28 at 75 degrees F mean temperature. Pipe insulation shall be Johns Manville Rubatex, Armstrong Armaflex II, or equal.
6. Locations and Class of Insulation Required: For thickness required, refer to Table 1 of this Section.

TABLE 3 – SERVICE, LOCATION AND CLASS OF INSULATION REQUIRED

|  |  |  |
| --- | --- | --- |
| SERVICE | LOCATION | CLASS OF INSULATION |
| Condensate drains from air conditioning equipment | Indoors at all locations including above ceilings and between stud walls | D |
| Refrigerant suctionLiquid line as required | All locations except underground | D |
| All other piping,except underground | All locations except underground | A, B, C |

1. Adhesives:
	1. Polystyrene adhesives: Synthetic rubber and resin adhesives specifically designed to adhere extruded and expanded rigid polystyrene and urethane insulation to themselves and to other porous and non-porous substrates.
	2. Vapor barrier laps and penetrations: Furnish protective coating and lagging adhesive on butt joints of foil-faced vapor barriers, and where pins and staples puncture facings.
	3. **HIGH TEMPERATURE EQUIPMENT INSULATION**
2. General:
3. Insulate heat exchangers, hot water storage tanks, flash tanks, boiler breechings, and similar equipment operating at elevated temperatures up to 450 degrees F or 850 degrees F with high temperature insulation, jacket and material.
4. Do not insulate condensate receivers, hot water expansion tanks, hot water pump casings, chemical feeders, and factory insulated boilers.
5. Materials:
6. Equipment insulation shall be 1½-inch minimum fiberglass board or insulating blocks, or molded calcium silicate, ASTM C533-Type I, Johns Manville Thermo-12, CertainTeed Fiberglass 1B board or Snap Wrap, Owens Corning 1-S Board or Kaylo Block.
7. Boiler breeching insulation shall be same as above except 2-inch thick minimum.
8. Adhesive: For calcium silicate, furnish fibrous adhesive of sodium silicate base.
	1. **LOW TEMPERATURE EQUIPMENT INSULATION**
9. General:
10. Insulate water chillers, heat exchangers, air eliminators and similar equipment operating at reduced surface temperatures.
11. Do not insulate chilled water expansion tanks, and chemical feeders.
12. Materials:
13. Expanded polystyrene, 2-inch thick, self-extinguishing type, Dow Chemical’s Styrofoam FR, Stauffer Chemical Co Structo-Foam, or equal, or 1-1/2” inches thick expanded urethane (polyurethane), self-extinguishing type, UpJohn Co CPR Division, Armstrong Expando-Foam, Owens-Corning Urethane, or equal.
14. Canvas Jackets: 6 ounce in accordance with square foot minimum.
15. Vapor Barrier Laps and Penetrations: Furnish protective coating and lagging adhesive on butt joints of foil-faced vapor barriers and where pins and staples puncture facings.
	1. **DUCTWORK AND PLENUM INSULATION**
16. General: Insulate ductwork and plenums with not less than the amount of insulation tabulated in Table 4, unless noted otherwise on the drawings. Insulation may be omitted under the following conditions:
17. Exposed return air ductwork in conditioned space.
18. Return air ductwork between wall studs inside an interior wall.

## TABLE 4 - INSULATION OF DUCTS AND PLENUM

|  |  |
| --- | --- |
| Duct Location | Insulation Type |
| Exposed interior round and oval supply air ductwork located at Gyms and MPR Stages | DW-1 |
| Exposed interior rectangular supply air ductwork located at Gyms and MPR Stages | L-1 |
|  |  |
| Exterior locations  | L-2 |
| In walls, within floor/ ceiling spaces  | F-1 or L-1 See note 3 |
| Hot and cold plenums  | F-2, DW-1 or L-2 See note 3 |
| Attics, Garages, and Crawl Spaces, within unconditioned space or in basement  | F-3 or L-2 See note 3 |

1. Insulation Types:
2. DW-1: 1” inch thick insulation sandwiched inside double-wall type ducts and fittings.
3. F-1: 1½-inch blanket fiberglass, factory-laminated with all-service jacket vapor barrier.
4. F-2: 2-inch blanket fiberglass, factory-laminated with all-service jacket vapor barrier.
5. F-3: 3-inch blanket fiberglass, factory-laminated with all-service jacket vapor barrier.
6. L-1: 1½-inch Internal duct lining.
7. L-2: 2-inch Internal duct lining.
8. Notes:
9. Minimum insulation provided shall be as required by the current California Mechanical Code Title 24 for the most restrictive condition.
10. Refer to the materials indicated in this section for external insulation & Internal Lining.
11. External insulation shall be replaced with internal duct lining (of equivalent thermal resistance value unless noted otherwise) where indicated on the drawings or specified elsewhere for sound attenuation.
12. Provide internal duct lining (1 ½-inch unless noted otherwise) where indicated on the drawings or specified elsewhere for sound attenuation.
13. All exterior insulated ductworks shall be water proofed at joints, seams and duct penetrations.
14. Materials:
15. Fire-Resistive Insulation Materials and Coatings: Submit State Fire Marshal pre-approved materials only.
16. Adhesives: See Paragraph 2.01.E for applicable products.
17. External Insulation: Provide glass fiber blankets that are factory-laminated with Foil Reinforced Kraft (FRK) vapor barrier facing; Johns Manville Microlite, Owens-Corning all-service faced duct wrap, Ultralite No. 100, Pittsburgh Plate Glass Superfine, or Silvercoat Silvercel. Provide a minimum installed R value as required by the CEC Building Energy Efficiency Standards; but not less than scheduled on Table 5:

## TABLE 5

## INSULATION OF DUCTS AND PLENUM INSTALLED

## THERMAL RESISTANCE “R” VALUES

|  |  |  |
| --- | --- | --- |
| Type | Labeled Thickness (in inches)  | Installed R Value (hr.ft2.°F/Btu) |
| F-1 | 1 ½ | 4.2 |
| F-2 | 2 | 5.6 |
| F-3 | 3 | 8.3 |
| DW-1 | 1 | 4.2 |
|  |  |  |
| L1 | 1 ½ | 6.0 |
| L2 | 2 | 8.0 |

1. Internal Lining: Internal Lining shall be of the type that inhibits the growth of mold, mildew and fungi and shall not contain harmful VOC’s or contain glass fiber. Johns Manville Permacote Linacoustic and/or Permacote Spiracoustic, Owens-Corning QuietR.
	1. Polyester Duct Liner:
	2. Polyester duct liner shall be an engineered nonwoven, thermally bonded Polyester with a smooth and durable FSK facing.
	3. Polyester duct liner must be able to withstand a constant internal temperature up to 250°F must be compliant with Greenguard Environmental Institute and contain zero VOCs per ASTM D5116. Liner must comply with all applicable standards including ASTM E84, ASTM C411, ASTM C518, ASTM G21, NFPA 90A and 90B, and UL 181.
	4. Approved Manufacturer: Ductmate Industries “PolyArmor” duct liner or approved equal.
	5. Elastomeric duct liner:
	6. Closed-cell, sponge- or expanded-rubber materials. Elastomeric liner must be able to withstand a constant internal temperature up to 300°F and must comply with all applicable standards including ASTM E84, ASTM E96, ASTM C209, ASTM C534 - Type II sheet materials, ASTM C411, ASTM C518, ASTM G21, ASTM G22, NFPA 90A and 90B, and UL 181.
	7. Approved Manufacturer: Armstrong World Industries, Imcoa.
	8. Duct liner must be attached per manufacturer’s requirements using a non-flammable, low VOC water-based adhesive. When applicable, apply a non-flammable, low VOC water-based lagging adhesive to the exposed leading edge of the insulation. Install fasteners per SMACNA HVAC Duct Liner installation instructions.
	9. Duct liner must be installed per SMACNA Manual, “HVAC Duct Construction Standards, Metal and Flexible,” Third Edition unless otherwise specified.

## PART 3 – EXECUTION

* 1. **INSTALLATION**
1. Except as specified herein, install material in accordance with recommendations of manufacturer. Do not install insulation materials until tests specified in other sections are completed. Remove foreign material such as rust, scale, or dirt. Surfaces shall be clean and dry. Maintain insulation clean and dry at all times.
2. On cold surfaces where a vapor barrier must be provided and maintained, insulation shall be installed with a continuous, unbroken moisture and vapor seal. Hangers, supports, anchors, or other projections that are fastened to cold surfaces shall be insulated and vapor sealed to prevent condensation.
3. Surface finishes shall be extended in such a manner as to protect raw edges, ends, and surfaces of insulation.
4. Pipe or duct insulation shall be continuous through walls, ceiling or floor openings, or sleeves; except where fire-stop or fire-safing materials are required.
5. Thermal shields shall be installed between hangers or supports and the piping insulation. Rigid insulation inserts shall be installed between the pipe and the insulation shields. Inserts shall be of equal thickness to adjacent insulation and shall be vapor sealed accordingly.
6. Insulation shall not be installed in the following locations unless otherwise noted:
7. On vacuum return lines less than 50 feet long.
8. On unions, flanged connections or valve handles.
9. Over edges of any manhole, clean-out hole, clean-out plug, access door or opening to a fire damper, so as to restrict opening or identification of access.
10. Over any label or stamp indicating make, approval, rating, inspection, or similar data, unless provision is made for identification and access to label or stamp.
	1. **INSTALLATION OF HEATING PIPING SYSTEM INSULATION**
11. General: Space heating hot water, domestic hot water, tempered water supply and return piping and condensate return piping, after having been tested, shall be cleaned and insulated.
12. Application: Insulate condensate return piping, hot water heating supply and return piping, steam and steam condensate piping, domestic hot water supply and return, including tempered supply and return piping in accordance with manufacturer's instructions and as specified herein.
13. Install insulation on valve bodies up to valve bonnet. Fill void in saddles, in accordance with Section 23 0513: Basic HVAC Materials and Methods, with insulation and seal joints.
14. Install insulating material to fittings, valves, and strainers and smooth to thickness of adjacent covering. Leave strainer clean-out plugs accessible. Covers fabricated from polyvinyl chloride shall be furnished.
15. Insulation Jackets in Exposed Indoor Locations:
16. Cover completed insulation with canvas jacket tightly pasted to covering with lagging adhesive. Lap jacket seams 1-1/2-inch minimum. Finish entire jacket with coating of undiluted adhesive.
17. Equivalent factory applied pre-sized, glass fiber reinforced, or glass fiber jackets may be furnished. Seal jacket seams with adhesive in accordance with manufacturer's instructions.
18. Zeston 2000 or equal, fitting covers may be furnished, with molded or segmented insulation equal to specified insulation applied to fittings. Secure covers in accordance with manufacturer's instructions.
19. In addition to above requirements, cover exposed insulated piping within a distance of 8 feet above floors with 26 gage galvanized steel jacket. Omit jacket in areas accessible only to maintenance personnel, such as mechanical equipment rooms, utility corridors, accessible pipe tunnels and manholes.
20. Concealed Indoor Locations: Cover insulation over fittings, valves, and strainers with canvas. Provide pipe insulation with factory or field applied standard jacket of 4-ounce minimum canvas, fiberglass cloth, or glass fiber reinforced jacket. Seal jacket laps with adhesive in accordance with manufacturer's instructions.
21. Exposed Outdoors: In addition to canvas or fiberglass cloth cover, pipe insulation exposed to weather shall be provided with an additional 0.016-inch thick aluminum jacket with 2-inches lap connected with 1-inch hem overlap joint located on side of pipe and turned down to shed water. Jacket shall be strapped 12-inch on center with ½-inch wide stainless-steel strapping and wing seals. Aluminum jacket shall be mitered to fit fittings.
	1. **INSTALLATION OF COOLING PIPING SYSTEM INSULATION**
22. General: Chilled water supply and return piping, refrigerant piping and condensate drain lines, after having been tested, shall be cleaned and insulated.
23. Application: Insulation on chilled water lines, refrigerant suction lines and liquid lines, if indicated, and air conditioner interior drain lines shall be jacketed with fire-resistant vapor barrier of laminated aluminum foil consisting of 2 plies with glass-yarn reinforcing. Jacket joints shall be lapped and sealed with an approved adhesive. Insulation shall be secured with aluminum bands not less than 0.005-inch thick by ¾-inches wide, spaced not over 12-inch on centers, or as recommended by manufacturer.
24. Longitudinal Seams: Butt hinged sections of covering tightly together and seal down jacket flap with adhesive, or with factory-applied, self-sealing lap with pressure-sensitive sealer protected with release paper.
25. End Joints: Wrap joint with a 3-inch wide (minimum) self-sealing tape.
26. Fittings and Valves: Fittings and valves shall be covered with same material of same thickness as pipe insulation, sealed with an approved, vapor-sealing tape or compound and covered with Zeston polyvinyl-chloride cover.
27. Pipe hangers shall be insulated or attached to pipe by an insulating insert, butted between adjoining insulation sections.
28. Additional Jackets:
29. Exposed Indoor Insulation: Cover with 26 gage galvanized sheet metal jacket to 8 feet above floors, except in mechanical equipment rooms and accessible pipe tunnels.
30. Exposed Outdoor Insulation: In addition to canvas or fiberglass cloth cover, provide 0.016-inch thick aluminum jacket with 1-inch wide aluminum bands and seals. Install appropriate jackets on valves and fittings.
	1. **INSTALLATION OF HIGH TEMPERATURE EQUIPMENT INSULATION**
31. General: Provide insulation over parts of heat exchangers and similar equipment requiring insulation having removable head or sections.
32. Application:
33. Equipment: Securely tie insulation on with copper clad wire. Install tack coat weather barrier coating at a thickness specified by manufacturer. While tack coat is still wet, a layer of 10 open weave glass cloth membrane shall be embedded with fabric seams overlapped a minimum of 2-inch. Install a finish coat fully covering membrane at coverage rate specified by manufacturer.
34. Boiler Breechings: Wire securely V-rib wire lath, ¾-inch minimum depth to boiler breechings, connections and stacks inside boiler rooms, and cover with insulation and jacket as specified above.
35. Manholes and Hand Holes: Maintain accessible by beveling off permanent insulation around manhole and cover manhole plate with removable blanket.
	1. **INSTALLATION OF LOW-TEMPERATURE EQUIPMENT INSULATION**
36. General: Provide removable sections of insulation over parts of chillers and similar equipment requiring insulation and having removable heads or sections.
37. Exterior surfaces of chilled water system expansion tanks and chilled water pumps shall be insulated with not less than 2-inch thick expanded polystyrene or fiberglass, as specified. Fill spaces between insulation and equipment with granulated polystyrene or urethane to eliminate voids. Insulation shall be secured with metal band, and covered with one inch, 20 gage hexagon galvanized mesh and ¼-inch thick insulating cement toweled smooth. Cement surface shall then be covered with 0.002-inch aluminum foil applied smoothly and secured with suitable adhesive, and a layer of 6-oz. canvas.
38. Coat joints of polyurethane insulation with neoprene based contact adhesive. Adhesives furnished shall be approved by insulation manufacturer. Fill and seal external voids and seams with non-shrinking sealant.
39. Canvas Jacket: Cover completed insulation with canvas jacket tightly pasted to covering with lagging adhesive. Lap jacket seams a minimum of 1 ½-inch. Finish entire surface of canvas jacket with one brush coat of diluted lagging adhesive, Childers CP-50A, Foster 30-36, Mon-Eco Industries (MEI) Eco-Lag Adhesive, or equal, and heavy final coat of undiluted adhesive.
	1. **INSTALLATION OF DUCTWORK AND PLENUM INSULATION**
40. External Covering:
41. Before installing duct insulation, sheet metal ducts shall be clean, dry, and tightly sealed at joints and seams, inspected pressure tested, and accepted by OAR/ Inspector.
42. Duct exterior insulation shall be firmly wrapped around ductwork with joints lapped a minimum of 2-inch. Insulation shall be securely fastened with 18 gage copper-lined steel wire, or 16 gage soft-annealed galvanized wire spaced approximately 12-inch on centers and at loose ends, presenting a neat and workmanlike appearance. Where duct width is such that wiring will not fasten insulation firmly against duct an adhesive shall be furnished to fasten insulation to duct with wiring being installed at ends of insulation segment.
43. Insulation on ductwork transporting conditioned air, both supply and return, and outside air intake ducts when pre-conditioned, shall be furnished with a factory-applied, fire-resistant vapor barrier.
44. Exposed Ducts or Plenum:
	1. Install insulation to ducts or plenum furnished with butt joints, without voids and with adhesive over entire surface of duct. Cover insulation with canvas jacket, fastened tightly to insulation with lagging adhesive. Install 2 finish coats of undiluted adhesive.
	2. When installing jacket, finished covering shall be even and level, without humps, with constant diameters on round ducts maintained.
45. Interior insulation - lining:
46. Dimensions of ducts indicated are net inside dimensions and must include thickness of duct liners to obtain the required duct size.
47. Install insulation in square turns, where required, to cover interior surfaces before duct turns are installed.
48. Install lining material during fabrication of duct with sealed face only exposed to air stream.
49. Interior insulation in ducts or plenums shall not have exposed edges. Edges open to entering or leaving air streams shall be covered, secured in place and sealed with approved duct liner edge sealers.
50. Insulation shall be fastened to sheet metal with an approved fire-retardant adhesive, with minimum 90 percent coverage and edges firmly adhered.
51. Mechanical fasteners shall supplement the adhesive on top sections of ducts more than 12-inch wide and on sides of ducts more than 24-inch high and shall be spaced on 16-inch centers maximum. Fastener posts shall be cut off approximately ¼-inch from metal disc.
	1. **CLEANUP**
52. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.
	1. **PROTECTION**
53. Protect the Work of this Section until Substantial Completion.

END OF SECTION