## SECTION 23 07 10
## MECHANICAL INSULATION

### PART 1 – GENERAL

#### 1. DESCRIPTION:

A. Field applied insulation for thermal efficiency and condensation control for HVAC piping, ductwork and equipment.

B. Definitions:
1. ASJ: All service jacket, white finish facing or jacket.
2. Air-conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
3. Cold: Equipment, ductwork, or piping handling media at design temperature of 60 degrees F or below.
4. Concealed: Ductwork and piping above ceilings and in chases, interstitial space, and pipe spaces.
5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including equipment rooms or exposed to outdoor weather. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
6. FSK: Foil-scrim-kraft facing.
7. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
8. Hot: HVAC Ductwork handling air at design temperature above 60 degrees F; HVAC equipment or piping handling media above 105 degrees F; boiler breechings, generator exhaust, grease hood exhaust, clothes dryer exhaust, and piping and equipment 90 to 450 degrees F.
9. Density: Pcf - pounds per cubic foot.
10. Runouts: Branch pipe connections up to one-inch nominal size to fan coil units or reheat coils for terminal units.
11. Thermal conductance: Heat flow rate through materials.
    a. Flat surface: BTU per hour per square foot.
    b. Pipe or Cylinder: BTU per hour per linear foot.
12. Thermal Conductivity (k): BTU per inch thickness, per hour, per square foot, per degree F temperature difference.
13. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.

**2. QUALITY ASSURANCE:**

A. Criteria:
1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, UL 181A, UL181B, ASTM C 411, ASTM E84, UL 723, or NFPA 255. Comply with SMACNA, ASHRAE and the codes in effect at the time of permitting.

B. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material

D. Where system components or equipment are found to be producing condensation, contractor shall re-insulate or add additional insulation as required to prohibit the formation of condensation

E. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
1. American Society for Testing and Materials (ASTM):
2. .. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
3. .. C411-2011 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
4. .. C449-2007 (R2013) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
5. .. C450-2008 (R2014) Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
6. .... Adjunct to C450 Compilation of Tables that Provide Recommended Dimensions for Prefab and Field Thermal Insulating Covers, etc.
7. .. C533-2013 Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
8. .. C534/C534M-2014 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
9. .. C547-2015 Standard Specification for Mineral Fiber Pipe Insulation
10. C552-2014 Standard Specification for Cellular Glass Thermal Insulation
11. C553-2013 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
12. C591-2013 Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
13. C680-2014 Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs
14. C612-2014 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
15. C1126-2014 Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

16. C1136-2012 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
17. C1710-2011 Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
18. D1668/D1668M-1997a (2014)e1 Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing
19. E84-2015a Standard Test Method for Surface Burning Characteristics of Building Materials
20. E2231-2015 Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation to Assess Surface Burning Characteristics
21. National Fire Protection Association (NFPA) 90A-2015 Standard for the Installation of Air-Conditioning and Ventilating Systems
22. Underwriters Laboratories, Inc (UL):
    i. 723-2008 (R2013) Standard for Test for Surface Burning Characteristics of Building Materials
    ii. .....1887-2004 (R2013) Standard for Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics

**3. SUBMITTALS:**

A. Shop Drawings:
All information, clearly presented, shall be included to determine compliance with drawings and specifications.
1. Insulation materials: Specify each type used and state surface burning characteristics.
2. Insulation facings and jackets: Each type used. Submittal shall clearly indicate proposed finishes for exposed ductwork, casings, pipe, and equipment.
3. Insulation accessory materials: Each type used.
4. Refer to applicable specification paragraph numbers for coordination.

**4. STORAGE AND HANDLING OF MATERIAL:**

A. Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

**PART 2 - PRODUCTS**

**1. MINERAL FIBER OR FIBER GLASS (INTERIOR):**

A. ASTM C612 (Board, Block), Class 1 or 2, density 3 pcf, k = 0.26 at 75 degrees F, external insulation for temperatures up to 400 degrees F with foil scrim (FSK) facing. Contractor shall select thickness so that installed insulation meets minimum R value required.

B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 2 pcf, k = 0.27 at 75 degrees F, for use at temperatures up to 400 degrees F with foil scrim (FSK) facing.

C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.26 at 75 degrees F, for use at temperatures up to 450 degrees F with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

**2. RIGID DUCT BOARD (EXTERIOR):**

A. Rigid glass fiber board; ANSI/ASTM C612; commercial grade; 8.0 installed 'R' value (minimum) at 75 degrees F, foil scrim kraft facing for air conditioning ducts (nominally 2" thick) exposed to the weather. Provide with aluminum weather proof jacketing and ensure that tops of ducts are 'tented' to prohibit the ponding of water. All seams in insulation and jacket shall be sealed water tight. Insulation shall be Certainteed, Certapro Commercial Board with FSK facing, type CB 300 (3.0 lb/cu.ft.) minimum density.

**3. CELLULAR GLASS CLOSED-CELL:**

A. Comply with Standard ASTM C552, density 7.5 pcf nominal, k = 0.29 at 75 degrees F.

B. Pipe insulation for use at process temperatures below ambient air to 900 degrees F with all service vapor retarder jacket (ASJ).

C. Pipe insulation for use at process temperatures for pipe and tube below ambient air temperatures or where condensation control is necessary are to be installed with a vapor retarder/barrier system of with all service vapor retarder sealed jacket (ASJ) system.

**4. FLEXIBLE ELASTOMERIC CELLULAR THERMAL:**

A. ASTM C534/C534M, k = 0.27 at 75 degrees F, flame spread not over 25, smoke developed not over 50, for temperatures from 40 degrees F to 199 degrees F. Under high humidity exposures for condensation control an external vapor retarder/barrier jacket is required. Consult ASTM C1710.

**5. DUCT WRAP FOR KITCHEN HOOD GREASE DUCTS:**

A. System to be NFPA 96 compliant.

B. Light weight, high temperature mineral fiber or ceramic fiber insulating material with low thermal conductivity K value of 0.417 Btu in/hr ft² degrees F at mean temperature of 500 degrees F.

C. Material shall be fully encapsulated by UL classified aluminum foil and tested to ASTM E84 standard.

D. Material shall be UL tested for internal grease fire to 2,000 degrees F with zero clearance and for through-penetration firestop.

E. Material shall be UL classified for 2 hour fire rating for grease duct enclosure, and meet NFPA 96 requirements for direct applied insulating material to grease ducts with zero clearance.

F. Material flame spread and smoke developed ratings shall not be higher than 5, as per ASTM E 84/UL 723 Flammability Test.

**6. CALCIUM SILICATE:**

A. Preformed pipe Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.

B. Premolded Pipe Fitting Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.

C. Equipment Insulation: ASTM C533, Type I and Type II

D. Characteristics:

| **Insulation Characteristics** | | |
|---|---|---|
| **ITEMS** | **TYPE I** | **TYPE II** |
| Temperature, maximum degrees F | 1200 | 1700 |
| Density (dry), lb/ ft3 | 14.5 | 18 |
| Thermal conductivity:<br>Min Btu in/h $ft^2$ degrees F@<br>mean temperature of 200 degrees F | (0.41) | 0.540) |
| Surface burning characteristics:<br>Flame spread Index, Maximum | 0 | 0 |
| Smoke Density index, Maximum | 0 | 0 |

**7. INSULATION FACINGS AND JACKETS:**

A. Vapor Retarder, high strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.

B. ASJ jacket shall be white kraft bonded to 1 mil thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 1-1/2 inch lap on longitudinal joints and minimum 3 inch butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork exposed to outdoor air (i.e.; in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity areas conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 30 inch-pounds for

interior locations and (80 inch-pounds for exterior or exposed locations or where the insulation is subject to damage.

E. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to composition A, Type II Grade GU, and Type III, minimum thickness 0.03 inches. Provide color matching vapor retarder pressure sensitive tape.

F. Aluminum Jacket-Piping systems and circular breeching and stacks: ASTM B209, 3003 alloy, H-14 temper, 0.023 inch minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.024 inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 0.5 inch wide on 18 inch centers. System shall be weatherproof if utilized for outside service.

**8. PIPE COVERING PROTECTION SADDLES:**

A. Pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass insulation of the same thickness as adjacent insulation.

B. Pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation.

C. Pipe supports: MSS SP58, Type 39. Apply at all pipe support points, except where MSS SP58, Type 3 pipe clamps provided as part of the support system.

| Nominal Pipe Size and Accessories Material (Insert Blocks) | |
|---|---|
| Nominal Pipe Size (inches) | Insert Blocks (inches) |
| Up through 5 | 6 long |
| 6 | 6 long |
| 8, 10, 12 | 9 long |
| 14, 16 | 12 long |
| 18 through 24 | 14 long |

**9. ADHESIVE, MASTIC, CEMENT:**

A. As recommended by insulation manufacturers' published recommendations.

B. Low VOC in accordance with SCAQM Rule 1168 requirements.

**10. MECHANICAL FASTENERS:**

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.

B. Staples: Outward clinching galvanized steel.

C. Wire: 18 gage soft annealed galvanized or 14 gage copper clad steel or nickel copper alloy.

D. Bands: 0.5-inch nominal width, brass, galvanized steel, aluminum, or stainless steel.

**11. REINFORCEMENT AND FINISHES:**

A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

B. PVC fitting cover: Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 40 degrees F to 250 degrees F. Provide color matching vapor barrier pressure sensitive tape.

**12. FLAME AND SMOKE:**

A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications.

**PART 3 – EXECUTION**

**1. GENERAL REQUIREMENTS:**

A. Required pressure tests of duct and piping joints and connections shall be completed. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 6 inches.

D. Install vapor stops with operating temperature 60 degrees F and below at all insulation terminations on either side of valves, pumps, fittings, and equipment and particularly in straight lengths every 15 to 20 feet of pipe insulation. The annular space between the pipe and pipe insulation of approx. 1 inch in length at every vapor stop shall be sealed with appropriate vapor barrier sealant.

E. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 20 gage galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.

F. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.

G. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable. Duct systems shall be tented on the top surface to ensure positive drainage of water from the surface.

H. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

I. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow and fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting.

J. Firestop Pipe and Duct insulation: Provide firestopping insulation at fire and smoke barriers through penetrations. All penetrations through rated assemblies will require fire stopping with a U.L. approved firestopping method.

K. Freeze protection of above grade outdoor piping over heat tracing tape: 1.5” thick cellular glass insulation for all pipe sizes. Provide metal jackets for all pipes. Provide for cold water make-up, condenser water piping, chilled water piping, drain piping at traps and other wetted pipe as required to prohibit freezing.

L. Provide vapor barrier jackets over insulation as follows: All piping and duct systems shall be provided with an integral vapor barrier unless noted otherwise.

M. Provide metal jackets over insulation as follows:
    1. All plumbing piping exposed to outdoor weather.
    2. Piping exposed in building, within 6 feet of the floor, that connects to sterilizers, kitchen and laundry equipment, piping in equipment rooms and piping drops subject to damage (janitor closets, etc.). Jackets may be applied with pop rivets except for cold pipe or tubing applications. Provide aluminum angle ring escutcheons at wall, ceiling, or floor penetrations.
    3. A 2-inch jacket overlap is required at longitudinal and circumferential joints with the overlap at the bottom.

N. Provide PVC jackets over insulation as follows:
    1. Piping exposed in building, within 6 feet of the floor, on piping that is not precluded in previous sections. PVC Jackets is not permitted in areas where pipe is subject to damage. PVC jackets may not be used on exterior piping.
    2. A 2-inch jacket overlap is required at longitudinal and circumferential joints with the overlap at the bottom.

**2. INSULATION INSTALLATION:**

A. Mineral Fiber Board and Rigid Duct Board:

1. Apply board on pins spaced not more than 12 inches on center each way, and not less than 3 inches from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
2. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, interstitial spaces and duct work exposed to outdoor weather:
    i. 2-inch-thick insulation faced with ASJ (white all service jacket): Supply air duct, return air duct, mixed air plenums and prefilter housing.
    ii. Outside air intake ducts: one-inch-thick insulation faced with ASJ.
    iii. Exposed, unlined supply and return ductwork exposed to outdoor weather: 2-inch-thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.
3. Supply air duct in the warehouse and in the laundry: one-inch-thick insulation faced with ASJ.
4. Chilled water pumps: Insulate with removable and replaceable 20 gage aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.
5. Flexible Mineral Fiber Blanket: Adhere insulation to metal with 3-inch-wide strips of insulation bonding adhesive at 8 inches on center all around duct. Additionally secure insulation to bottom of ducts exceeding 24 inches in width with pins welded or adhered on 18-inch centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
6. Molded Mineral Fiber Pipe and Tubing Covering: Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on ducts and piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports.
7. Cellular Glass Insulation: Pipe and tubing, covering nominal thickness as specified in the schedule at the end of this section. Install per manufacturer's instructions.
8. Cold equipment: 2-inch-thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, buffer tanks, air separators and air purgers.
9. Hot equipment: 1-1/2 inch thick insulation faced with ASJ.
    i. Convertors, air separators, steam condensate pump receivers.
    ii. Reheat coil casing and separation chambers on steam humidifiers located above ceilings.
    iii. Domestic water heaters and hot water storage tanks (not factory insulated).
    iv. Booster water heaters.

10. Flexible Elastomeric Cellular Thermal Insulation: Apply insulation and fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
    i. Pipe and tubing insulation: Use proper size material. Do not stretch or strain insulation.
    ii. Where possible, slip insulation over the pipe or tubing prior to connection and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
    iii. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
11. Duct Wrap for Kitchen Hood Grease Ducts: The insulation thickness, layers and installation method shall be as per recommendations of the manufacturer to maintain the fire integrity and performance rating. Maintain 2 hour rated assembly with zero clearance. Provide stainless steel jacket for all exterior and exposed interior ductwork.
12. Laundry: Hot exhaust ducts from dryers and from ironers, where duct is exposed in the laundry.

B. Flexible Mineral Fiber Blanket:
    1. Adhere insulation to metal with 3 inch wide strips of insulation bonding adhesive at 8 inches on center all around duct. Additionally secure insulation to bottom of ducts exceeding 24 inches in width with pins welded or adhered on 18 inch centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
    2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
    3. Concealed supply air ductwork.
        i. Above ceilings at a roof level, in attics, and duct work exposed to outdoor weather: 2 inch thick insulation faced with FSK.
        ii. Above ceilings for other than roof level: 1 ½ inch thick insulation faced with FSK.
    4. Concealed return air duct:
        i. In attics (where not subject to damage) and where exposed to outdoor weather: 2 inch thick insulation faced with FSK,
        ii. Above ceilings at a roof level, unconditioned areas, and in chases with external wall or containing steam piping; 1-1/2 inch thick, insulation faced with FSK.
        iii. In interstitial spaces (where not subject to damage): 1-1/2 inch thick insulation faced with FSK.
    5. Concealed outside air duct: 1-1/2 inch thick insulation faced with FSK.

C. Molded Mineral Fiber Pipe and Tubing Covering:
   1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
   2. Contractor's options for fitting, flange, and valve insulation:
      i. Insulating and finishing cement for sizes less than 4 inches operating at surface temperature of 60 degrees F or more.
      ii. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 40 degrees F, or above 250 degrees F. Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
      iii. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 60 degrees F or less, vapor seal with a layer of glass fitting tape imbedded between two 1/16 inch coats of vapor barrier mastic.
      iv. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 2 inches.
   3. Nominal thickness specified in the schedule at the end of this section.

D. Flexible Elastomeric Cellular Thermal Insulation:
   1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
   2. Pipe and tubing insulation:
      i. Use proper size material. Do not stretch or strain insulation.
      ii. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer.
   3. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
   4. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
   5. Pipe insulation: nominal thickness in inches as specified in the schedule at the end of this section.
   6. Use Class S (Sheet), 3/4 inch thick for the following:
      i. Chilled water pumps
      ii. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
      iii. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
      iv. Piping inside refrigerators and freezers: Provide heat tape under insulation.

E. Duct Wrap for Kitchen Hood Grease Ducts:
   1. The insulation thickness, layers and installation method shall be as per recommendations of the manufacturer to maintain the fire integrity and performance rating.
   2. Provide stainless steel jacket for all exterior and exposed interior ductwork.

F. Calcium Silicate:
   1. Minimum thickness in inches specified in the schedule at the end of this section.
   2. Engine Exhaust Insulation for Emergency Generator and Diesel Driven Fire Pump: Type II, Class D, 2 1/2 inch nominal thickness. Cover exhaust completely from engine through roof or wall construction, including muffler. Secure with 16 AWG galvanized annealed wire or 0.015 x 1/2 IN wide galvanized bands on 12 IN maximum centers. Anchor wire and bands to welded pins, clips or angles. Apply 1 IN hex galvanized wire over insulation. Fill voids with 1/4 IN insulating cement.

**3. COMMISSIONING (IF REQUIRED):**

A. Provide commissioning documentation in accordance with the requirements of the commissioning plan for all inspection, start up and contractor testing required above and required by the Commissioning Agent.

**4. INSULATION SCHEDULES:**

A. Piping

| SERVICE | PIPE SIZE | INSULATION TYPE AND THICKNESS |
|---|---|---|
| Refrigerant Suction and Liquid Pipes (except in plenums or fire wall penetrations) | All | 1" Elastomeric |
| Refrigerant Suction and Liquid Pipes (in plenums or fire wall or floor penetrations) | All | 1-1/2" Cellular Glass w/ ASJ |
| Coil Condensate Lines (except in plenums or fire wall penetrations) | All | ½" Elastomeric |
| Coil Condensate Lines (in plenums or fire wall or floor penetrations) | All | 1-1/2" Cellular Glass w/ ASJ |

B. Ducting

| SERVICE | SIZE | INSULATION TYPE AND THICKNESS |
|---|---|---|
| Supply, Return and Outdoor Air Ductwork (Interior Concealed) | All | 2" Thick Fiberglass Duct Wrap with Tape and Mastic Sealed Seams. R-6.0 Minimum. |

| | | |
|---|---|---|
| Supply, Return and Outdoor Air Ductwork (Exposed to Outdoor Conditions) | All | 2" Thick Rigid Ductboard w/ Tented Aluminum Jacket. R-8.0 Minimum. |
| Supply, Return and Outdoor Air Ductwork (Interior Exposed, Finished Space) | All | Double Wall Duct with 1" Integral Insulation. Paint Grip Exterior Finish. |
| Supply, Return and Outdoor Air Ductwork (Interior Exposed, Unfinished Space) | All | 1.5" Thick Rigid Ductboard Liner w/ FSK facing. |
| Relief, Exhaust and Transfer Ductwork | All | 1" Thick Rigid Ductboard Liner w/ FSK facing. Only Use Where Indicated. |
| Equipment Operating Under Dewpoint or Subject to Condensation | All | 2" Thick Fiberglass Duct Wrap with Tape and Mastic Sealed Seams. R-6.0 Minimum. |
| Kitchen Grease Exhaust | All | Fire-Wrap to Maintain 2 Hour Rating and Zero Clearance. |
| Tops of Supply Air Diffusers | All | 2" Thick Fiberglass Duct Wrap with Tape and Mastic Sealed Seams. R-6.0 Minimum. |

**END OF SECTION 23 07 10**