

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. HVAC piping insulation, jackets and accessories.
2. HVAC equipment insulation, jackets and accessories.
3. HVAC ductwork insulation, jackets and accessories.
4. Insulation for engine exhaust pipes.

B. Related Sections:

1. Division 07 - Firestopping: Product requirements for firestopping for placement by this section.
2. Division 09 - Painting and Coating: Execution requirements for painting insulation jackets and covering specified by this section.
3. Section 23 51 00 - Engine Exhaust Stacks.

1.02 REFERENCES

A. ASTM International:

1. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
3. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
4. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
5. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
6. ASTM C450 - Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
7. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.

8. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
9. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
10. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
11. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
12. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
13. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
14. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
15. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
16. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
17. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
18. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
19. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
20. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
21. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.
22. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
23. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
24. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
25. Con Edison Specification S-9021-6.

B. Sheet Metal and Air Conditioning Contractors':

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

- C. National Fire Protection Association:
 - 1. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- D. Underwriters Laboratories Inc.:
 - 1. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
 - 2. UL 1978 - Standard for Safety for Grease Ducts.

1.03 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.
- C. Samples: Submit two samples of representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.04 QUALITY ASSURANCE

- A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84, UL 723 and NFPA 258.
- B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.
- C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.
- D. Perform Work in accordance with IBC-NJ.

1.05 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Applicator: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
- C. Maintain temperature before, during, and after installation for minimum period of 24 hours.

1.08 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Manufacturers for Glass Fiber and Mineral Fiber Insulation Products:
 - 1. CertainTeed.
 - 2. Knauf.
 - 3. Johns Manville.
 - 4. Owens-Corning.
 - 5. Substitutions: Division 01 - Product Requirements.
- B. Manufacturers for Closed Cell Elastomeric Insulation Products:
 - 1. Aeroflex. Aerocell.
 - 2. Armacell, LLC. Armaflex.
 - 3. Nomaco. K-flex.
 - 4. Substitutions: Division 01 - Product Requirements.
- C. Furnish materials in accordance with IBC-NJ.

2.02 PIPE INSULATION

- A. TYPE P-1: ASTM C547, molded glass fiber pipe insulation.
 - 1. Thermal Conductivity: 0.23 at 75 degrees F (0.034 at 24 degrees C).
 - 2. Operating Temperature Range: 0 to 850 degrees F (minus 18 to 454 degrees C).
 - 3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.
 - 4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).
 - 5. Density 10 PCF average.
- B. TYPE P-3: ASTM C612; semi-rigid, fibrous glass board noncombustible, end grain adhered to jacket.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).
 - 2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).
 - 3. Vapor Barrier Jacket: ASTM C1136, Type II, factory applied reinforced foil kraft with self-sealing adhesive joints.
 - 4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).
 - 5. Density 10 PCF average.
- C. TYPE P-4: ASTM C612; semi-rigid, fibrous glass board noncombustible.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F (0.040 at 24 degrees C).
 - 2. Operating Temperature Range: 0 to 650 degrees F (minus 18 to 343 degrees C).
 - 3. Density 10 PCF average.
- D. TYPE P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 25 degrees C).
 - 2. Operating Temperature Range: Range: Minus 70 to 180 degrees F (minus 57 to 82 degrees C).
- E. TYPE P-6: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.
 - 1. Thermal Conductivity: 0.30 at 75 degrees F (0.043 at 24 degrees C).
 - 2. Maximum Service Temperature: 300 degrees F (149 degrees C).
 - 3. Operating Temperature Range: Range: Minus 58 to 300 degrees F (minus 50 to 149 degrees C).

- F. TYPE P-7: ASTM C534, Type I, flexible, nonhalogen, closed cell elastomeric insulation, tubular.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 24 degrees C).
 - 2. Maximum Service Temperature: 250 degrees F (120 degrees C).
 - 3. Operating Temperature Range: Range: Minus 58 to 250 degrees F (minus 50 to 120 degrees C).
- G. TYPE P-8: ASTM C547, Type I rigid, mineral fiber preformed pipe insulation, noncombustible.
 - 1. Thermal Conductivity: 0.23 at 75 degrees F (0.034 at 24 degrees C).
 - 2. Maximum Service Temperature: 1200 degrees F (649 degrees C).
 - 3. Reinforced Fail Vapor Retarding Jacket: UL listed and treated with fire retardant lagging adhesive. ASTM E93.
 - 4. Consisting of single layer thickness to comply with requirement.

2.03 PIPE INSULATION JACKETS

- A. PVC Plastic Pipe Jacket:
 - 1. Product Description: ASTM D1784, One piece molded type fitting covers and sheet material, off-white color.
 - 2. Thickness: 10 mil (0.25 mm).
 - 3. Connections: Pressure sensitive color matching vinyl tape.
- B. Aluminum Pipe Jacket:
 - 1. ASTM B209.
 - 2. Thickness: 0.016 inch (0.40mm) thick sheet.
 - 3. Finish: Smooth.
 - 4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
 - 5. Fittings: 0.016 inch (0.4 mm) thick die shaped fitting covers with factory attached protective liner.
 - 6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 3/8 inch (10 mm) thick aluminum.
- C. Field Applied Glass Fiber Fabric Jacket System:
 - 1. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
 - 2. Glass Fiber Fabric:

- a. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - b. Blanket: 1.0 lb/cu ft (16 kg/cu m) density.
 - c. Weave: [5 x 5] [10 x 10] [10 x 20].
- 3. Indoor Vapor Retarder Finish:
 - a. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - b. Vinyl emulsion type acrylic, compatible with insulation, white color.
- D. Outdoor pipe (insulated): Aluminum jacket all around insulation secured with aluminum or stainless steel bands at maximum 12 inches on center.

2.04 PIPE INSULATION ACCESSORIES

- A. Vapor Retarder Lap Adhesive: Compatible with insulation.
- B. Covering Adhesive Mastic: Compatible with insulation.
- C. Piping 1-1/2 inches (40 mm) diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.
- D. Piping 2 inches (50 mm) diameter and larger: Steel saddle. Inserts length: not less than 6 inches (150 mm) long, matching thickness and contour of adjoining insulation.
- E. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- F. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449/C449M.
- G. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.
- H. Adhesives: Compatible with insulation.

2.05 EQUIPMENT INSULATION

- A. TYPE E-2: ASTM C612; glass fiber, rigid board, noncombustible with factory applied reinforced aluminum foil jacket.
 - 1. Thermal Conductivity: 0.24 at 75 degrees F (0.035 at 24 degrees C).
 - 2. Operating Temperature Range: 0 to 450 degrees F (minus 18 to 232 degrees C).
 - 3. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).
 - 4. Jacket Temperature Limit: minus 20 to 150 degrees F (minus 29 to 66 degrees C).
- B. TYPE E-5: ASTM C612; glass fiber, semi-rigid board, noncombustible.
 - 1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).

2. Maximum Operating Temperature: 850 degrees F (450 degrees C).
 3. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).
- C. TYPE E-7: ASTM C612-93; Type V, thermafiber board, asbestos free.
1. Thermal Conductivity: 0.46 at 400 degrees F (0.0664 at 227 degrees C).
 2. Maximum Operating Temperature Range: 1900 degrees F (1038 degrees C).
 3. Density: 18.5 PCF
- D. TYPE E-8: ASTM C534, Type II, flexible, closed cell elastomeric insulation, sheet.
1. Thermal Conductivity: 0.27 at 75 degrees F (0.039 at 25 degrees C).
 2. Operating Temperature Range: Range: Minus 70 to 220 degrees F (minus 57 to 105 degrees C).

2.06 EQUIPMENT INSULATION JACKETS

- A. Aluminum Equipment Jacket:
1. ASTM B209.
 2. Thickness: 0.016 inch (0.40 mm) thick sheet.
 3. Finish: Smooth.
 4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
 5. Fittings: 0.016 inch (0.4 mm) thick die shaped fitting covers with factory attached protective liner.
 6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.
- B. Field Applied Glass Fiber Fabric Jacket System:
1. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
 2. Glass Fiber Fabric:
 - a. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - b. Blanket: 1.0 lb/cu ft (16 kg/cu m) density.
 - c. Weave: 10 x 10.
 3. Indoor Vapor Retarder Finish:
 - a. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - b. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.07 EQUIPMENT INSULATION ACCESSORIES

- A. Vapor Retarder Lap Adhesive: Compatible with insulation.

2.08 DUCTWORK INSULATION

- A. TYPE D-1: ASTM C1290, Type III, flexible glass fiber, commercial grade with factory applied reinforced aluminum foil jacket meeting ASTM C1136, Type II.
 - 1. Thermal Conductivity: 0.25 at 75 degrees F (0.036 at 24 degrees C).
 - 2. Maximum Operating Temperature: 250 degrees F (121 degrees C).
 - 3. Density: 1.5 pound per cubic foot (24 kilogram per cubic meter).
- B. TYPE D-2: ASTM C612, Type IA or IB, rigid glass fiber, with factory applied all service facing meeting ASTM C1136, Type II.
 - 1. Thermal Conductivity: 0.22 at 75 degrees F (0.032 at 24 degrees C).
 - 2. Density: 4.25 pound per cubic foot (68 kilogram per cubic meter).
- C. Type D-3: Fire-wrapping for kitchen exhaust duct, smoke control duct stair pressurization and other locations indicated on the drawings.
 - 1. Fire-rated flexible duct wrap insulation shall be assembled and tested in accordance with ISO 6944, ASTM E-814/UL 1479, ASTM E-84/UL 723, ASTM E-136 and ASTM C-518.
 - 2. The assembly shall comply with IBC-NJ and IMC.
 - 3. One layer of wrapping shall have 2 hours F-rating and 2 hours T-rating.
 - 4. Minimum 6 pound per cubic foot density.
 - 5. Product from Scrim Encapsulated.
 - 6. OTCR approved.
 - 7. Accepted Manufactures:
 - a. 3M.
 - b. Unifrax Corp.
- D. TYPE D-4: ASTM C1071, Type I, flexible, glass fiber duct liner with coated air side.
 - 1. Thermal Conductivity: 0.24 at 75 degrees F (0.036 at 24 degrees C).
 - 2. Density: 1.5 pound per cubic foot (24 kilogram per cubic meter).
 - 3. Maximum Operating Temperature: 250 degrees F (121 degrees C).

4. Maximum Air Velocity: 2,000 feet per minute (30.5 meter per second).
 5. 1 inch minimum.
 6. Treated with EPA register anti-microbial agent proven to resist microbial growth as determined by ASTM G-21 and G-22.
- E. TYPE D-5: ASTM C1071, Type II, rigid, glass fiber duct liner with coated air side.
1. Thermal Conductivity: 0.23 at 75 degrees F (0.033 at 24 degrees C).
 2. Density: 3.0 pound per cubic foot (48 kilogram per cubic meter).
 3. Maximum Operating Temperature: 250 degrees F (121 degrees C).
 4. Maximum Air Velocity: 4,000 feet per minute (20.3 meter per second).
 5. 1 inch minimum.
 6. Treated with EPA register anti-microbial agent proven to resist microbial growth as determined by ASTM G-21 and G-22

2.09 DUCTWORK INSULATION JACKETS

- A. Outdoor Duct Jacket: Flexible self-adhering weatherproof system similar to Flex Clad 250.
- B. Membrane Duct Jacket: ASTM D4637; Type I, EPDM; non-reinforced, 0.060 inch 1.5 mm) thick, 48 inch (1220mm) wide roll; white color.

2.10 DUCTWORK INSULATION ACCESSORIES

- A. Vapor Retarder Tape:
 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- B. Vapor Retarder Lap Adhesive: Compatible with insulation.
- C. Adhesive: Waterproof, ASTM E162 fire-retardant type.
- D. Liner Fasteners: Galvanized steel, welded with integral head.
- E. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- F. Lagging Adhesive: Fire resistive to ASTM E84, NFPA 255 and UL 723.
- G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.
- H. Adhesives: Compatible with insulation.
- I. Membrane Adhesives: As recommended by membrane manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Division 01 - Administrative Requirements: Coordination and project conditions.
- B. Verify piping, equipment and ductwork have been tested before applying insulation materials.
- C. Verify surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION - PIPING SYSTEMS

- A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations. Provide PVC jacket around insulation.
- B. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 84 00 for penetrations of assemblies with fire resistance rating greater than one hour.
- C. Piping Systems Conveying Fluids Below Ambient Temperature:
 - 1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump and expansion joints.
 - 2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 - 3. Insulate fittings, joints, valves and all appurtenances with molded insulation of like material and thickness as adjacent pipe. Finish with PVC fitting covers.
- D. Glass Fiber Board Insulation:
 - 1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
 - 2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
 - 3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.
- E. Hot Piping Systems less than 140 degrees F (60 degrees C):
 - 1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.

2. Insulate fittings, joints, valves and all appurtenances with molded insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.
 3. Insulate unions and flanges.
- F. Hot Piping Systems greater than 140 degrees F (60 degrees C):
1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
 2. Insulate fittings, joints, valves and all appurtenances with molded insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.
 3. Insulate flanges and unions.
- G. Inserts and Shields:
1. Piping 1-1/2 inches (40 mm) Diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.
 2. Piping 2 inches (50 mm) Diameter and Larger: Install saddle between support shield and piping and under finish jacket.
 - a. Insert Configuration: Minimum 6 inches (150 mm) long, of thickness and contour matching adjoining insulation; may be factory fabricated.
 - b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.
 3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.
 4. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapor barrier where required. Insulation inserts shall be not less than following lengths:

2-1/2 in. pipe size and smaller	6 in. long
3 in. to 6 in. pipe size	9 in. long
8 in. to 10 in. pipe size	12 in. long
larger than 10 in. pipe size	18 in. long
- H. Insulation Terminating Points:
1. Ducted Coil Branch Piping: Terminate hot water piping at the coil connections including coil header.
 2. Chilled Water Coil Branch Piping: Insulate chilled water piping and associated components up to coil connection.
 3. Condensate Piping: Insulate entire piping system and components to prevent condensation.
- I. Closed Cell Elastomeric Insulation:
1. Push insulation on to piping.

2. Miter joints at elbows.
 3. Seal seams and butt joints with manufacturer's recommended adhesive.
 4. When application requires multiple layers, apply with joints staggered.
 5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.
- J. High Temperature Pipe Insulation:
1. Install single layer to meet thickness scheduled. Multiple layers of insulation will not be accepted.
 2. All insulation surfaces not in shaft construction, shall maintain a maximum of 100°F for piping insulation and 130°F for equipment insulation.
 3. Stagger joints between jackets.
 4. Supplied with pre-formed jacket.
- K. Piping Exterior to Building: Provide vapor retarder jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor retarder cement. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water or on bottom side of horizontal piping.
- L. Buried Piping: Insulate only where insulation manufacturer recommends insulation product may be installed in trench, tunnel or direct buried. Install factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with 1 mil (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with polyester film.
- M. Heat Traced Piping Interior to Building: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracing.
- ~~N. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces: Aluminum jacket and fitting covers.~~
- O. Heat Traced Piping Exterior to Building: Insulate fittings, joints, valves and all appurtenances with molded insulation of like material, thickness, and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water.
- P. Prepare pipe insulation for finish painting. Refer to Division 09.
- Q. Insulate enclosed engine exhaust pipes to meet a surface temperature of not more than 200°F when enclosed in shaft. Insulate engine exhaust pipes that are not enclosed to meet a surface temperature of not more than 100 °F.
- R. Insulation at Strainers: Provide removable insulation.

3.03 INSTALLATION - EQUIPMENT

- A. Factory Insulated Equipment: Do not insulate.
- B. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
- D. Equipment Containing Fluids Below Ambient Temperature:
 - 1. Insulate entire equipment surfaces.
 - 2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
 - 3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 - 4. Finish insulation at supports, protrusions, and interruptions.
- E. Equipment Containing Fluids 140 degrees F (60 degrees C) Or Less:
 - 1. Insulate flanges and unions with removable sections and jackets.
 - 2. Install insulation with factory-applied or field applied jackets, with vapor barrier. Finish with glass cloth and adhesive.
 - 3. Finish insulation at supports, protrusions, and interruptions.
- F. Equipment Containing Fluids Over 140 degrees F (60 degrees C) Or Less:
 - 1. Insulate flanges and unions with removable sections and jackets.
 - 2. Install insulation with factory-applied or field applied jackets, with vapor barrier. Finish with glass cloth and adhesive.
 - 3. Finish insulation at supports, protrusions, and interruptions.
- G. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with aluminum jacket.
- H. Equipment Located Exterior to Building: Install vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.
- I. All parts of equipment subject to sweating and condensation shall be field insulated with specified insulation or minimum 1-1/2 inch thick insulation, whichever is greater by the contractor.

- J. Cover glass fiber, cellular glass, hydrous calcium silicate insulation with metal mesh and finish with heavy coat of insulating cement and aluminum jacket.
- K. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.
- L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.
- M. Prepare equipment insulation for finish painting. Refer to Division 09.

3.04 INSTALLATION - DUCTWORK SYSTEMS

- A. Duct dimensions indicated on Drawings are finished inside dimensions.
- B. Insulated ductwork conveying air below ambient temperature:
 - 1. Provide insulation with vapor retarder jackets.
 - 2. Finish with tape and vapor retarder jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- C. Insulated ductwork conveying air above ambient temperature:
 - 1. Provide with or without standard vapor retarder jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- ~~D. Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet (3 meters) above finished floor): Finish with aluminum jacket.~~
- E. External Glass Fiber Duct Insulation:
 - 1. Secure insulation with vapor retarder jacket with wires and seal jacket joints with vapor retarder adhesive or tape to match jacket.
 - 2. Secure insulation without vapor retarder jacket with staples, tape, or wires.
 - 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
 - 4. Seal vapor retarder penetrations by mechanical fasteners with vapor retarder adhesive.

5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- F. Duct and Plenum Liner:
1. Adhere insulation with adhesive for 100 percent coverage.
 2. Secure insulation with mechanical liner fasteners. Comply with SMACNA Standards for spacing.
 3. Seal and smooth joints. Seal and coat transverse joints.
 4. Seal liner surface penetrations with adhesive.
 5. Cut insulation for tight overlapped corner joints. Support top pieces of liner at edges with side pieces.
 6. Provide metal nosings at section joints.
- G. Ducts Exterior to Building:
1. Install insulation according to external duct insulation paragraph above and weatherproof all around.
 2. Provide external insulation with vapor retarder jacket. Provide tin at corners and flood coat with at least three heavy coats of mastic. Install insulation and jacketing with slope so that water drains along sides and does not accumulate on top of the duct.
 3. Finish with membrane duct jacket.
 4. Calk seams at flanges and joints. Located major longitudinal seams on bottom side of horizontal duct sections.
- H. Prepare duct insulation for finish painting. Refer to Division 09.

3.05 SCHEDULES

A. Cooling Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches (mm)
Chilled Water Supply and Return 40 to 60 degrees F, heat recovery system piping	P-1	All	1.5 (40) 1.5 (40)
Cold water piping	P-1	All	1.0 (25)
Condensate Piping from Cooling Coils	P-5	All sizes	0.75 (19)
Refrigerant	P-5	All	1.5 (40)

B. Heating Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS inches (mm)
Heating Water Supply and Return 141 to 200 degrees F (61 to 93 degrees C)	P-1	1-1/2 inches (40 mm) and smaller 2 inches (50 mm) to 8 inches (100 mm)	1.5 (40) 2.0 (50)
Heating Water Supply and Return 141 to 200 degrees F (61 to 93 degrees C)	P-2	10 inches (200 mm) and up	2.5 (65)
Low Pressure Steam Supply and condensate return up to 15 psi (103 kPa) up to 250 degrees F (121 degrees C)	P-1 P-3	1-1/2 inches (40 mm) and smaller 2 inches (50 mm) and up	1.5 (40) 3.0 (75)
Drain Piping	P-1	All sizes	1 (25)

C. Equipment Insulation Schedule:

EQUIPMENT	INSULATION TYPE	INSULATION THICKNESS inches (mm)
Steam-to-Water Heat Exchanger, hot water expansion tanks, air separators, hot water pumps and accessories	E-5	1.5 (40)
Water-to-Water Heat Exchangers	E-2	1.5 (40)
Steam Condensate Receivers	E-2	1.5 (40)
Condensate Tanks, humidifiers	E-2	1.5 (40)
Chilled Water Pump Bodies	E-8	1.0 (25)
Chilled Water Air Separators	E-8	1.0 (25)
Chilled Water Expansion Tanks	E-8	1.0 (25)
Chiller Cold Surfaces (Not Factory Insulated)	E-8	1.0 (25)
Generator Exhaust Muffler	E-7	4.0 (100)

D. Ductwork Insulation Schedule:

DUCTWORK SYSTEM	INSULATION TYPE	INSULATION THICKNESS inches (mm)
Outside Air Intake ducts, plenums, casings	D-2	2 (50)
Equipment Casings	D-2	2 (50)
Supply Ducts (internally insulated) in MER's or as specified	D-4	1.5 (40)
Return Ducts (internally insulated) in MER's or as specified	D-4	1.5 (40)
Supply and Return Ducts located above hung ceilings that are not internally insulated	D-1	1.5 (40)
Return Ducts located above hung ceilings or in shaft	D-1	1.5 (40)
Supply and Return ducts in MER's and exposed to view	D-2	1.5 (40)
Spill/exhaust ducts from louver to motorized damper	D-2	1.5 (40)
Supply, Return Duct Exterior to building on roof	D-2	2.0 (50)
Exhaust Ducts Within 10 feet (3 m) of Exterior Openings [Thickness indicated is installed thickness.]	D-2	1.5 (40)
Exhaust Ducts Exposed to Outdoor Air	D-2	2.0 (50)
Rectangular Supply Ducts Downstream of Variable Air Volume Boxes (internally insulated)	D-4	1.5 (40)
Rectangular and Round Supply Ducts Downstream of Variable Air Volume Boxes (externally insulated)	D-1	1.0 (25)
Round Supply Ducts Downstream of Variable Air Volume Boxes (externally insulated)	D-1	1.0 (25)
Transfer Air Ducts (internally insulated)	D-4	1.0 (25)
Glasswash, cage wash exhaust air	D-4	2.0 (50)

Refer to Section 23 05 48 "NOISE AND VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT" for specific applications of internally insulated ducts.

END OF SECTION