PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
   1. Ductwork Insulation:
      a. Duct wrap insulation.
      b. Acoustic duct lining.
      c. Rigid board ductwork and plenum insulation.
      d. Fire Rated duct insulation systems.
      e. Field applied jackets, indoor and outdoor.
   2. Section Includes insulating the following duct services:
      a. All supply air ductwork, unless otherwise shown on drawings.
      b. Return air ductwork in unconditioned spaces and as shown on drawings.
      c. Acoustical duct lining, in vertical/horizontal supply and return ducts within twenty feet (20’) of air handling equipment and where otherwise shown on drawings.
      d. Exhaust air ductwork in cold air plenums.
      e. Vapor/moisture ductwork.
   3. Piping Insulation:
      a. Piping insulation.
      b. Insulation Jackets
      c. Removable Covers.
   4. Section includes the following HVAC piping systems:
      a. Heating hot water supply and return piping.
      b. Chilled water supply and return piping.
      c. Condenser water supply and return piping.
      d. Steam and condensate return piping.
      e. Valves, pumps, air separators, strainers and fittings in insulated piping systems.
   5. HVAC equipment insulation - section includes the following HVAC equipment that is not factory insulated:
      a. Heat exchangers.
      b. Converters.
      c. Chilled-water pumps.
      d. Heating hot-water pumps.
      e. Steam condensate pumps.
      f. Air separators.
      g. Steam condensate tanks.

B. Types of mechanical insulation specified in this Section include the following:
   1. Duct wrap insulation: Fiberglass.
   2. Acoustic duct liner: Fiberglass.

3. Fire-rated duct insulation: Fire rated blanket.
4. Pipe insulation: Fiberglass.
5. Pipe insulation: Flexible elastomeric closed cell foam.
6. Equipment insulation: Fiberglass.
7. Equipment insulation: Flexible elastomeric closed cell foam.
8. Insulation jackets.
9. Removable covers
10. Insulation accessories.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

C. Section 232113: HVAC Piping, Valves and Specialties.

1.4 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 33° F, as stated in ASHRAE fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space whose airstream is not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:

a. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
b. C165 - Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
c. C167 - Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.
d. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission.
e. Properties by Means of the Guarded-Hot-Plate Apparatus.
f. C195 - Specification for Mineral Fiber Thermal Insulating Cement.
g. C196 - Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
h. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
i. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
j. C305 - Test for Thermal Conductivity of Pipe Insulation.
k. C356 - Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
l. C411 - Test for Hot-Surface Performance of High Temperature Thermal Insulation.
m. C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
n. C449 - Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
o. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p. C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
q. C921 - Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
r. C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
s. C1071 - Standard Specification for Thermal and Acoustical Insulation.
t. C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
u. E84 - Test Method for Surface Burning Characteristics of Building Materials.
v. E119 - Test for Fire Resistance.
w. G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
x. G22 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90 - Energy Conservation in New Building Design.
3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.

b. 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
c. 255 – Standard Method of Test of Surface Burning Characteristics of Building Materials.

4. Underwriter's Laboratories (UL):
   a. UL 723 – Test for Surface Burning Characteristics of Building Materials.

B. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

C. Corrosiveness: Provide insulation such that when tested in accordance with the following test, the steel plate in contact with the insulation shows no greater corrosion than sterile cotton in contact with a steel plate for comparison.
   1. Test Specimen: Two specimens shall be used, each measuring 1" by 4" by approximately 1/2" thick.
   2. Apparatus: Provide a humidity test chamber in which two polished-steel test plates, 1" wide, 4" long and 0.020" thick, shall be placed. Plates shall be clear finish, cold-rolled strip steel, American quality, quarter hard, temper No. 3, weighing 0.85 lb/sq. ft.
   3. Procedure: The steel test plates shall be rinsed with cp benzol until their surfaces are free from oil and grease and allowed to dry. One piece of cold-rolled steel shall be placed between the two insulation specimens and secured with tape or twine. The test specimen and uncovered plate shall be suspended vertically in an atmosphere having a relative humidity of 95% (plus or minus 3%), and a temperature of 120°F (plus or minus 3°F), for 96 hours, and then be examined for corrosion.

D. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

E. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9)
   2. Octabrominated diphenyl ether (CAS#32536-52-0)
   3. Decabrominated diphenyl ether (CAS#1163-19-50

1.6 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also furnish necessary test data certified by an independent testing laboratory. Submit samples.

B. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9)
   2. Octabrominated diphenyl ether (CAS#32536-52-0)
   3. Decabrominated diphenyl ether (CAS#1163-19-50

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Johns Manville, Owens-Corning, Knauf, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix, or approved equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.2 DUCT WRAP INSULATION:

A. Type DW-A Flexible Fiberglass Blanket: Johns Manville Microlite XG, formaldehyde-free, recycled content; Knauf ECOSE Duct Wrap; or equal:
   1. Application: Insulation wrap for ductwork, or other HVAC systems.
   2. 'K' Value: ASTM C553-92, 0.27 Btu•in./(hr•ft²•°F) at 75°F installed full thickness.
   3. Density: 0.75 lb/cu ft.
   4. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with fiberglass yarn and laminated to fire-resistant kraft.
   5. Installation: See Part 3-Execution below.

2.3 ACOUSTIC DUCT LINER:

A. Type ADL-A. Fiberglass Acoustic Duct Liner: Johns Manville Duct Liner RC with Anti-Microbial Acrylic Coating or equal:
   1. Application: Duct lining for acoustic or thermal purposes.
   2. 'K' Value: ASTM 1071, 0.23 Btu•in./(hr•ft²•°F) at 75°F.
   3. Noise Reduction Coefficient: 0.65 or higher based on "Type A mounting."
   4. Maximum Velocity on Mat or Coated Air Side: 5,000 ft/min.
   5. Adhesive: UL listed waterproof type compliant with ASTM C916.
   6. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.

2.4 FIRE-RATED INSULATION SYSTEMS

A. Type FRI-D. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is UL tested and certified to provide a 2-hour fire rating.
   1. Products:
      a. CertainTeed Corp.; FlameChek.
      b. Johns Manville; Firetemp Wrap.
      c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
      d. Thermal Ceramics; FireMaster Duct Wrap.
      e. 3M; Fire Barrier Wrap 15A.
      f. Unifrax Corporation; FyreWrap.
      g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

2.5 FIELD APPLIED DUCTWORK INSULATION JACKETS

A. Field Applied Jackets (For Interior Applications):
   1. All longitudinal seams shall be located on bottom of ductwork
   2. PVC Plastic: Johns Manville Zeston 2000. One piece molded type fitting covers and jacketing material, gloss white. Connect with tacks and pressure sensitive color matching vinyl tape.

2.6 PIPE INSULATIONS

A. Glass Fiber: Molded fibrous glass pipe insulation shall comply with the requirements of ASTM C 547 and meet ASTM C 585 for sizes required in the particular system.
   1. Type PI-A: Fiberglass, Non-Wicking:
      a. Manufacturers:
         1) Johns Manville Micro-Lok HP ASJ SSL jacket up to 18” or FSK faced Micro-Flex for pipe sizes larger than 18”.
         2) Knauf
         3) einsulation
      b. Applications: Insulation of piping up to 3” thick insulation.
      c. 'K' Value: 0.23 at 75°F.
      d. Maximum Service Temperature: 850°F.
      e. Vapor Retarder Jacket: ASJ SSL white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secure with self sealing longitudinal laps and butt strips.

B. Type PI-F: Flexible Elastomeric Closed Cell Thermal Insulation: Armacel AP Armaflex, Rubatex K-Flex ECO, Aeroflex Aerocel, closed-cell, halogen free, elastomeric insulation. Comply with ASTM-C177, ASTM E 84 and UL 181.
   1. ‘K’ Value: 0.27 at 75°F.
   2. Density: 3.0 to 6.0 lbs./cu.ft.
   3. Maximum Service Temperature: 260°F.
   4. Seal all seams and joints with contact adhesive.

C. Field Applied Jackets (For Interior Applications):
   1. All longitudinal seams shall be located on bottom of pipes.
   2. PVC Plastic: Johns Manville Zeston 2000. One piece molded type fitting covers and jacketing material, gloss white. Connect with tacks and pressure sensitive color matching vinyl tape.
   3. Canvas Jacket: UL listed fabric, 6 oz/sq. yd. plain weave cotton, treated with dilute fire retardant lagging adhesive.
   4. Aluminum Jacket: 0.016” thick sheet, [smooth/embossed] finish, with longitudinal slip joints and 2” laps, die shaped fitting covers with factory

attached protective liner.

5. Secure aluminum jackets with 3/8” or ½” stainless steel bands on 12” centers.

D. Field Applied Jackets (For Exterior Applications):
1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
2. Aluminum Jacket: 0.016” (minimum) thick sheet, smooth or embossed finish, with longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner.
3. Stainless Steel Jacket: Type 304 stainless steel, 0.010” minimum (smooth/corrugated) finish.
4. Secure stainless steel or aluminum jackets with 3/8” or 1/2” stainless steel bands on 12” centers.
5. Manufacturers: Pabco, Childers, RPR, or equal.

E. Removable Covers:
1. Provide removable covers on pumps, valves, air separators, air vent fittings, flanges, strainers, steam traps, etc., where periodic maintenance or removal of insulation may is required.
2. Use of pre-molded fittings with PVC covers is acceptable, unless noted otherwise.
   a. Cold systems: Provide PVC covers on elbows.
   b. Cold systems: Provide Armaflex elastomeric foam for flanges, valves, pumps and strainers.
   c. Hot systems: provide PVC covers on elbows and flanges.
   d. Hot Systems: provide removable blanket covers on valves, pumps, and strainers.
3. Removable- type silicon cloth fiberglass filled insulating blankets:
   a. Mfg: Fit Tight Covers, GLT products, or equal custom fabrication by Insulation Contractor, 0-350°F service operating temperature:
      1) Jacket: silicon impregnated fiberglass cloth
      2) Liner: silicon impregnated fiberglass cloth
      3) Liner reinforcement: sstl mesh cloth
      4) Insulation: 1” type E glass matt
      5) Fastening: 2” nomex Velcro
      6) Fastening: 1” straps and stainless steel D-rings
      7) Fastening: 12 gage stainless steel hooks and stainless steel wire
      8) Thread: Kevlar/stainless steel thread
   b. Mfg: Fit Tight Covers, or equal custom fabrication by Insulation Contractor, 351-450°F service operating temperature:
   c. Jacket: silicon impregnated fiberglass cloth
   d. Liner: silicon impregnated fiberglass cloth
   e. Liner reinforcement : stainless steel mesh cloth
   f. Insulation: 2” type E glass matt
   g. Fastening: 2” nomex Velcro
   h. Fastening: 1” straps and stainless steel D-rings
   i. Fastening: 12 gage stainless steel hooks and stainless steel wire
   j. Thread: Kevlar/stainless steel thread

2.7 EQUIPMENT INSULATIONS

A. Flexible Fiberglass Blanket: Johns Manville Microlite Type 75 Flexible Blanket:
   1. 'K' Value: ASTM C518, 0.27 Btu•in./(hr•ft²•°F) at 75°F installed full thickness.
   2. Maximum Service Temperature: 250°F.
   3. Density: 0.75 lb/cu ft.
   4. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with fiberglass yarn and laminated to fire-resistant kraft, secured with UL listed pressure sensitive tape and/or outward clinched expanded staples and vapor barrier mastic as needed.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping and ductwork has been tested for leakage in accordance with specifications before applying insulation materials. All piping and ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.2 INSTALLATION

A. General:
   1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
   2. Remove and replace any insulation that has become wet or damaged during the construction process.
   3. Continue insulation and vapor barrier at penetrations and duct supports, except where prohibited by code. Instances where this is required include:
      a. Ductwork support angle or struts. To prevent crushing of low density insulation, provide separator or high density insulation at point of support. A 12 inch wide strip of 6 pcf density fiberglass board across the bottom side of the duct. Vapor barrier to continue unbroken at point of support.

B. Ductwork –Insulation on the Duct Exterior:
   1. Provide insulated ductwork conveying air below ambient temperature (below room temperature) with vapor retardant jacket.
   2. Seams/joints of duct wrap shall be secured with outward clinching galvanized staples spaced 4” on center. Vapor barrier tape shall not be used at the sole means of securing the insulation.
   3. Seal all vapor retardant jacket seams and penetrations with 3” wide pressure-sensitive vapor barrier tape matching the insulation facing.
   4. Provide insulated ductwork conveying air above ambient temperature (above room temperature) with or without vapor retardant jacket. Where service access is required, bevel and seal ends of insulation.
   5. All exposed exterior metallic ductwork exposed or covered with cladding is to be built with a crown or reverse cross break to shed moisture.
   6. Continue insulation through walls, sleeves, hangers, and other duct penetrations except where prohibited by code.

7. The insulation shall be firmly wrapped around the ducts with all joints lapped a minimum of 2" and secured with staples spaced 4" on center. The vapor barrier shall be sealed with FSK or metallic pressure sensitive tape. Installed thickness shall not exceed 25% compression. The underside of duct work 24" or greater in width shall be secured with mechanical fasteners and speed clips spaced approximately 18" on center. The protruding ends of the fasteners shall be cut off flush after the speed clips are installed, and then, when required, sealed with the same tape as specified above.
8. For ductwork exposed in mechanical equipment rooms below 7' or in finished spaces, finish with Johns Manville Zeston 2000 PVC jacket, or equal.
9. For interior vapor/moisture conveying duct applications, install fiberglass insulation unless specifically indicated otherwise on drawings. Install to meet manufacturer's requirements and as required by local code authorities.
10. For exterior applications, provide insulation with a weather protection jacket.
11. For exterior vapor duct applications, install fiberglass insulation with weatherproof jacket.

C. Duct Liner:
1. Liner is to be installed in vertical duct risers, mechanical shafts conveying return air, terminal box discharge plenums, and other horizontal duct runs where shown on drawings. Dimensions of lined ducts given on the drawings indicate the inside dimensions of duct after the lining has been installed.
2. Adhere insulation to sheet metal with a UL listed adhesive and as recommended by insulation manufacturer. Adhesive shall be applied to the sheet metal with a minimum coverage of 90%.
3. Secure insulation with mechanical liner fasteners as indicated by SMACNA or manufacturer. Pin length should be as recommended by the liner manufacturer.
   a. When width of duct exceeds 12" and also on sides when height exceeds 24", use non-ferrous mechanical fasteners such as welded pins and speed clips, 12" on center maximum lateral spacing and 18" on center maximum longitudinal spacing. Start fastening within 3" of upstream transverse edge of the liner and within 3" of the longitudinal joint. Mechanical fasteners shall not pierce the duct walls. The pins shall be cut off flush, washers shall be used and installation made so that no gaps or loose edges occur in the insulation. Top pieces shall be supported by the side pieces.
4. All edges of the liner must be factory or field coated. Unless factory coated, all transverse edges and longitudinal joints of the duct liner shall be coated. For systems operating at 4,000 fpm or higher, a metal nosing must be installed in all liner leading edges. All exposed edges, not abutting other liner, shall be installed with sheet metal nosing to protect the exposed edge and hold the liner firmly in place.
5. Repair liner surface penetrations with UL listed adhesive.
6. Duct dimensions indicated on plans are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.

D. Piping Insulation: Insulation shall be provided to the entire system chilled water, heating hot water and steam piping systems included but not limited to fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, steam moisture separators and expansion joints.
1. Locate insulation and cover seams in least visible locations unless

otherwise specified.

2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Provide insulated dual temperature pipes and cold pipes conveying fluids below ambient temperature with vapor retardant jackets with self sealing laps. Insulate complete system. No staples shall be used on pipes conveying fluids below ambient temperatures (cold systems).
4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
5. Provide insert between support shield and piping on piping 1-1/2” diameter or larger. Fabricate of Johns Manville Thermo-12, or other heavy density insulating material suitable for temperature. Insulation inserts shall not be less than the following lengths:
   a. 1½" to 2½" pipe size: 10" long
   b. 3" to 6" pipe size: 12" long
   c. 8" to 10" pipe size: 16" long
   d. 12" and over: 22" long
6. Use of metal saddles is acceptable as specified in Section 230500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
7. Use of pipe hangers designed as an insulation coupling is acceptable in lieu of saddles and other devices. Klo-Shure coupling or equal.
8. For pipe exposed in mechanical equipment rooms or in finished spaces below 7 feet above finished floor, finish with Johns Manville Zeston 2000 PVC jacket and fitting covers.
9. Where pumps, valves, strainers, etc., with insulation require periodic opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
   a. Cold systems: Provide Armaflex elastomeric foam for pumps and strainers.
   b. Hot Systems: provide removable blanket covers on valves, pumps, and strainers.
10. For exterior applications:
   a. Provide weather protection jacket. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. Jacket seams shall be located on bottom side of horizontal piping. All lateral joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).
   b. Apply weather-resistant protective finish such as WB Armaflex to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping. All lateral and longitudinal joints to be sealed with low V.O.C., UV inhibitive adhesive, such as Armaflex 520 BLV adhesive.
11. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.
12. Special Application Requirements for Chilled Water Systems:
   a. Fiberglass insulation is not allowed.
   b. Pipe: Provide closed cell phenolic foam or cellular glass insulation for chilled and low temperature heat recover water piping and fittings.

c. Non-factory vapor retarded piping and fittings: Spiral wrap insulation with Saran Vapor Retarder tape for fittings and. Cover with PVC jacket.
d. 90/45/tee fittings: Provide material routed out of bun stock to the shape of the elbow, cut in half and applied to the fitting and spiral wrapped with Saran Vapor retarder tape. Cover with PVC fitting cover.
e. Installation shall conform to Trymer Supercel or Pittsburg-Corning Foamglas installation guide.
f. Valves, pipe flanges, pumps, strainers, gage fittings: may use Armaflex closed cell insulation in lieu of phenolic foam.

E. Equipment Insulation:
1. See Piping Insulation above for additional requirements.
2. Apply insulation as close as possible to equipment by grooving, scoring, and beveling insulation, if necessary. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands, per manufacturer's recommendations.
3. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retardant cement.
4. Provide insulated dual temperature equipment or cold equipment containing fluids below ambient temperature with vapor retardant jackets.
5. For insulated equipment containing fluids above ambient temperature, provide jacket with or without vapor barrier.
6. Cover insulation with metal mesh and finish with heavy coat of insulating cement, mastic, or aluminum jacket as indicated in the drawings.
7. For equipment in mechanical equipment rooms or in finished spaces, finish with Johns Manville Zeston 2000 jacketing and fitting covers or aluminum or stainless steel jacketing.
8. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.
9. When equipment with insulation requires periodic opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage. Use of silicon cloth fiberglass filled lace-on type insulation blankets is acceptable.

3.3 DUCTWORK INSULATION SCHEDULE

A. All insulation thicknesses shall meet or exceed state energy code and mechanical code requirements as noted below. Minimum thermal resistance in range of 4.2 to 4.6 per inch of thickness. Insulation thicknesses are based on fiberglass insulation and may be adjusted for equivalent insulation values for materials with superior "K" factors.

B. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:
1. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
2. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.
3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

C. All air distribution system ducts and plenums, but not limited to, building cavities, mechanical closets, air handler boxes, and support platforms uses as ducts or plenums, shall be installed, sealed , and insulated to meet the requirements of the code. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum level of R-8.

1. Outdoors; or
2. In a space between the roof and an insulated ceiling; or
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or
4. In an unconditioned crawlspace; or
5. In other unconditioned spaces.

D. TABLE 1: DUCT WRAP INSULATION SERVICE, THICKNESS, AND MATERIAL TYPE REQUIRED.

Flexible Duct wrap:

SYSTEM	THICKNESS (inches)	FINISH	REMARKS/MATERIAL OPTIONS
Supply ducts and plenums within building envelope	1-1/2	FSK	Type DW-A,B,~~C~~
Supply or return duct installed as exposed ductwork in the occupied space.	0		Except where noted on drawings for acoustical reasons.
Supply or return or outside air duct installed as exposed ductwork in the occupied clean rated space.	1-1/2	Mylar	Applies to ISO rated Cleanroom spaces. Type DW-A,B
Return ducts and plenums within building envelope	1-1/2	FSK	Type DW-A,B
Exterior/Outside supply and return ductwork sandwiched in double wall sheet metal	2-1/2	FSK	* or a thickness resulting in compressed R value=8
Supply and return ductwork located outdoors and as described in 3.3.C above.	3		Type DW-A,B,C
Exhaust ducts within 10 ft. of exterior openings	2	FSK	Type DW-A,B,C

Thicknesses in the above table shall have insulation values as follows: 1” = R-4.2, 1-1/2” = R-6.3, 2” = R-8.0. Greater thicknesses are permitted to achieve identical values if space constraints allow.

E. TABLE 2: DUCTWORK RIGID INSULATION AND PLENUM INSULATION SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

Rigid and Plenum Insulation:

SYSTEM	THICKNESS (inches)	FINISH	REMARKS/MATERIAL OPTIONS
Outside air intake ducts	2	FSK	Provide aluminum jacket over

			exterior installations. Type RB-A,B
Interior Plenums	2	FSK	Type RB-A,B
Exterior Plenums	2	FSK	Type RB-A,B
Supply, return and relief ducts in mechanical rooms and parking garages	2	FSK	Type RB-A,B
Vapor/moisture ducts installed exterior to the building envelope.	1-1/2	FSK	Provide jacketing on exterior ducts. Type RB-A,B
Exterior ductwork sandwiched in double wall sheet metal	2	FSK	Type RB-A,B

F. TABLE 3: ACOUSTIC DUCT LINER SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

Acoustic Duct Liner (rectangular ductwork):

SYSTEM	THICKNESS (inches)	FINISH	REMARKS/MATERIAL OPTIONS
Where indicated	1” unless otherwise noted on plans	Air stream side coating	Type ADL-A,B,C,D
Discharge plenum from terminal units (VAV and CAV boxes)	1” unless otherwise noted on plans	Air stream side coating	Type ADL-A,B,C,D
Exterior ductwork where indicated in double wall sheet metal sandwich construction.	2	Air stream side coating	Type ADL-A,B,C,D
Within 20’ of Air Handling Unit in supply and return ducts	1	Air stream side coating	Type ADL-A,B,C,D

Acoustic Duct Liner (round ductwork):

SYSTEM	THICKNESS (inches)	FINISH	REMARKS/MATERIAL OPTION
Where indicated	1	Air stream side coating	Type ADL-E

Thicknesses in the above table shall have insulation values as follows: 1” = R-4.2, 1-1/2” = R-6.3, 2” = R-8.0. Greater thicknesses are permitted to achieve identical values if space constraints allow.

3.4 PIPING INSULATION SCHEDULE

A. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Listed insulation thicknesses shall be increased by 1/2” (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior “K” factors.

B. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED

SERVICE	FLUID TEMPERATURE RANGE (°F)	INSULATION TYPE / ALLOWED OPTIONS	REMARKS
Cooling Coil Condensate drain piping	(40°F -60°F)	Type PI-F	Provide 1/2" thickness insulation, all pipe sizes
Chilled water supply and return systems and fittings.	(40°F -60°F)	Type PI- B, E	All piping exposed on roof shall be insulated with Type PI-B only
Chilled water supply and return systems and fittings.	(39°F and below)	Type PI-B, E	All piping exposed on roof shall be insulated with Type PI-B only
Heating Water supply and return systems and fittings	(up to 200°F)	Type PI-A, PI-B, C, D, E, F	All piping exposed on roof shall be insulated with Type PI-B only
Low pressure steam supply and condensate systems	(250°F and below)	Type PI-A, C, D, E	
Medium and High pressure steam supply and Condensate systems	(greater than 250°F)	Type PI-A, C, D, E	
Steam condensate pump discharge systems	(141°F-200°F)	Type PI-A, C, D, E	
Steam Safety Valve Vent piping systems		Type PI-A, C, D, E	Provide 1" insulation thickness, all piping sizes. Provide aluminum jacket on exterior insulated piping

C. TABLE 2: MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.

Insulation Based on California T-24 Energy Code Table 120.3-A Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	**CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)**	**INSULATION MEAN RATING TEMPERATURE (°F)**	**NOMINAL PIPE DIAMETER (in inches)**				
			<1	**1 and 1-1/4**	**1-1/2 to <4**	**4 to <8**	**8 and larger**
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water) and Domestic Services Water Heating Systems							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.31	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.22-0.28	100	1.0	1.5	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.27	75	1.0	1.5	1.5	1.5	1.5

3.5 EQUIPMENT INSULATION SCHEDULE

A. Equipment not factory insulated, including but not limited to:
1. Heat exchangers.

2. Converters.
3. Chilled-water pumps.
4. Outdoor condenser-water pumps.
5. Heating, hot-water pumps.
6. Heat-recovery pumps.
7. Steam condensate pumps.
8. Expansion/compression tanks.
9. Air separators.
10. Steam flash tanks, flash separators, moisture separators, and blow-off tanks.
11. Hydronic service valves.
12. Steam and condensate service valves, 2” and larger.

B. Flexible Elastomeric Foam (Closed Cell):

SERVICE	THICKNESS (inches)	REMARKS
Chilled water pump bodies	1-1/2	
Chilled water, heat recovery water system valves ½" and larger	1-1/2	
Chilled water, heat recovery water air separator	1-1/2	
Chilled water, heat recovery water expansion/compression tanks	1-1/2	

C. Removable Fiberglass Insulated Silicone Cloth Covers with Closure:

SERVICE	THICKNESS (inches)	REMARKS
Heating water air separators	1-1/2	
Heating water expansion/compression tanks	1-1/2	
Heating water pump bodies	2	
Heating water system valves, 2-1/2” and larger	2	
LP Steam system valves, 2” and larger	2	
MP, HP Steam system valves, 2” and larger	2	
Steam condensate system valves, 2” and larger	2	
Steam Condensate receivers	2	
Steam condensate system pump bodies	2	

END OF SECTION