

## **XPS PIPE INSULATION BILLET IN REFRIGERATION APPLICATIONS (-70°F to 35°F)**

### **1. SCOPE**

- 1.1 This guideline covers the installation of XPS Pipe Billet Insulation on refrigeration piping systems, including associated vessels, tanks, and equipment. Guidelines are provided for both indoor and outdoor applications.
- 1.2 Since the upper temperature limit for XPS Insulation is 165°F, it must not be used on any pipe, valves, or equipment that will exceed this limit.
- 1.3 Product data sheets and other JM literature are referenced throughout this guideline. Visit <http://www.jm.com> for the latest version of these documents.
- 1.4 The information contained in this guideline and referenced JM documents are current as of January 2, 2020. This guideline is subject to revision without notice. Contact JM Insulation System Customer Information Group at 1-800-231-1024 or your local JM Representative for the most recent version of this guideline or other JM referenced literature.
- 1.5 Due to the variations in service conditions and use, this guideline may not be pertinent for every application. A design or specifying engineer can create specifications tailored to particular applications or contractor's needs. Such a design or specification engineering service may be more familiar with local conditions, budgets, environment, and the desired service life of the system allowing them to generate a more specific guideline.
- 1.6 It is the intent of this document to provide guidelines for the installation of XPS Pipe Billet Insulation manufactured by The Dow Chemical Company and SARANEX® Vapor Retarder Film and Tape manufactured by Transcendia, Inc. This guideline may not be suitable and shall not be used for the purpose of installing another insulation manufacturer's products. While supplemental insulation products may be referenced in this guideline, Dow recommends consulting the manufacturers of such products for proper installation and handling.
- 1.7 This guideline is offered as a guide for the purpose described herein. No warranty of procedures, either expressed or implied is intended. All other express or implied warranties of merchantability or fitness for a particular purpose are disclaimed.

### **2. GENERAL**

- 2.1 All piping shall be free of foreign substances and free of surface moisture or frost prior to the application of insulation.
- 2.2 All insulation material shall be delivered to the project site in original, unbroken factory packaging labeled with product designation and thickness. Shipment of materials from the manufacturer to the installation location shall be in weather-tight transportation. Insulation materials delivered to the job-site shall be stored so as to protect the materials from moisture and weather during storage and installation. Insulation material shall be protected from sunlight to avoid

exposure to UV light from the sun.

- 2.3 All testing of piping systems shall be completed prior to the installation of the insulation system.
- 2.4 Refer to the insulation thickness charts in Appendix C to determine recommended insulation thickness based on desired design criteria for ambient and service conditions.

### **3. MATERIALS OF CONSTRUCTION**

#### **3.1 INSULATION MATERIALS FOR PIPING, FITTINGS, AND VALVES**

- 3.1.1 Insulation shall be XPS Pipe Billet Insulation manufactured by The Dow Chemical Company.
- 3.1.2 Insulation shall be a minimum 1.6 lb./ft density (26 kg/m).
- 3.1.3 Insulation shall have a maximum thermal conductivity of 0.288 btu-in/hr.-ft -°F at 75°F mean temperature and 5 years aging (0.042 W/m-°C).
- 3.1.4 Insulation shall have a minimum compressive strength in the parallel to rise direction of 20 lb./in (138 kPa) per ASTM D 1621.
- 3.1.5 Insulation shall have a maximum water absorption of 0.5% by volume per ASTM C-272 and a maximum water vapor permeability of 1.5 perm-inch per ASTM E-96, procedure b.
- 3.1.6 Insulation dimensional stability at 158°F / 97% R.H. for 7 days shall be a maximum of 2% volume change as measured by ASTM D-2126.
- 3.1.7 Insulation pieces shall be manufactured from a minimum 7" thick billet so as to minimize laminations during fabrication.

#### **3.2 FABRICATION OF INSULATION**

- 3.2.1 Insulation shall be fabricated in required shapes from billets in accordance with ASTM C-450 "Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments" and ASTM C-585 "Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)". Insulation shall be factory fabricated from billets.
- 3.2.2 Fittings, such as valves, valve stations, flanges, 90° and 45° elbows, and tees shall be two-piece fly-cut or routed as the preferred fabrication method. For diameters too large for fly-cutting or routing, the pieces shall be fabricated in two halves with each half made up of mitered sections. Both methods shall be in accordance with ASTM C-450 and C-585. Larger outer diameter valves and flanges may be slightly oversized, and cavities filled with tightly packed loose fiberglass or polyurethane spray foam (see Figure 1 in Appendix B). The size and number of cavities shall be kept to a minimum. Refer to applications sections 4.1.3 and 4.1.4 for related additional information.
- 3.2.3 Store the XPS billets at normal shop (indoor) conditions for at least 24 hours before fabrication. This will allow the XPS billets to equilibrate to the

shop conditions. For factory applied vapor retarders, the fabricated pipe shells may be aged for 24 hours before vapor retarder attachment. Similarly, after fabrication of the fittings/elbows/tees, allow the cut pieces to age for 24 hours before factory application of the vapor retarder to the fabricated pieces. After application of vapor retarder, fabricated pipe shells shall not be stored for more than one month either in the warehouse or at a job site.

### **3.3 ADHESIVES, JOINT SEALERS AND MASTICS**

- 3.3.1 Do not use solvent-based adhesives, joint sealers or mastics in contact with XPS Insulation. Review adhesive manufacturer's information for proper compatibility with polystyrene prior to use. Mastics shall remain flexible at the lowest expected ambient temperature.
- 3.3.2 Joint sealers for sealing joints of insulation or PVC jacketing slip joints shall be vapor retarder type, moisture and water resistant, non-hardening, and flexible with the service temperature range from -50°F to +200°F.
- 3.3.3 A vapor retarder type mastic or joint sealers should be applied on insulation longitudinal joints and butt joints to prevent moisture and moisture vapor infiltration. Typical mastic can be CHIL-PERM WB CP-35, and joint sealer can be CHIL- JOINT CP-70 or approved equal. Other mastics are AK-CRYL CP-9, VI-CRYL CP-10/11 or approved equal. These products are from Childers Products Company. Please consult mastic or joint sealant manufacturer for recommended products.
- 3.3.4 Water based adhesives may be used to attach the SARANEX Film to the outer surface of the XPS insulation for factory applied SARANEX Film. Refer to the SARANEX Vapor Retarder Film and Tape installation guidelines. Consult adhesive manufacturer's literature for instructions on handling adhesives including required operating temperatures. Potential adhesives for use in this application include:
  - a) Foster 85-50 adhesive (water based)
  - b) Childers CP 56 adhesive (water based))
  - c) Foster 85-60 adhesive (water based)

### **3.4 VAPOR RETARDER**

- 3.4.1 Vapor retarder shall be SARANEX 540 Vapor Retarder Film for service temperatures above 32°F and SARANEX 540 or 560 Vapor Retarder Film in services at and below 32°F or where a permeance of 0.02 perm or better is required. Refer to ASTM standards C-755 and C-1136 for information on selection and specification of vapor retarders. Refer to product literature and installation guidelines on SARANEX Film for recommended application instructions.
- 3.4.2 Elbows and fittings shall be wrapped with SARANEX 520 Vapor Retarder Tape. When operating temperature is  $\leq 32^{\circ}\text{F}$  or when a permeance of 0.02 perms or better is required, elbows and fittings shall be wrapped with SARANEX 520 Vapor Retarder Tape with a 50% overlap. When operating temperature is  $> 32^{\circ}\text{F}$ , elbows and fittings shall be wrapped with a

single layer of SARANEX 520 Tape. When the nominal pipe size is 6" or less, use 1" wide SARANEX 520 tape. When the nominal pipe size is between 6" and 12", use 2" wide SARANEX 520 tape. When nominal pipe size is 12" or greater, use 3" wide SARANEX 520 tape.

- 3.4.3 When operating temperature is  $\leq 32^{\circ}\text{F}$  or when a permeance of 0.02 perms or better is required, butt joints shall be wrapped with either two layers of 3-inch wide SARANEX 520 Vapor Retarder Tape or a single layer of 3-inch wide SARANEX 560 Tape. When operating temperature is  $> 32^{\circ}\text{F}$ , butt Joints shall be wrapped with a single layer of 3-in wide SARANEX 520 Tape.
- 3.4.4 Vapor Retarder shall have a maximum permeance of 0.020 perm for applications at or below 32°F and a maximum permeance of 0.030 perm for applications above 32°F.
- 3.4.5 Vapor retarder may be factory or field applied to the outer surface of pipe insulation.
- 3.4.6 For tanks, vessels, and equipment, use SARANEX 540 or 560 Vapor Retarder Film or approved equal.

### **3.5 PROTECTIVE JACKETING MATERIALS**

#### **3.5.1 Indoor Applications**

- 3.5.1.1 Jacketing shall be PVC material. Consult jacketing manufacturer for recommended PVC thicknesses. Typical thicknesses are 0.010 to 0.030". Jacketing shall be tough and capable of enduring frequent wash-downs with hot water or cleaning agents. All joints of PVC jacket shall be solvent welded to prevent moisture and moisture vapor infiltration into the insulation system.
- 3.5.1.2 Supply preformed PVC covers for all fittings, tees, elbows, valves, caps, etc. at same PVC thickness as on straight pipe sections.
- 3.5.1.3 PVC protective jacketing shall not be considered a vapor retarder. See section 3.4 for Vapor Retarder recommendations.
- 3.5.1.4 Neither rivets, screws, staples nor any other fastener capable of penetrating the underlying vapor retarder shall be used to secure the PVC jacketing.

#### **3.5.2 Outdoor Jacketing**

- 3.5.2.1 Jacketing shall be aluminum metal cladding. Jacketing shall be aluminum alloys 3003, 1100 or 3105 meeting ASTM B- 209 with H-14 temper a minimum of 2 ½ mil thickness polyfilm moisture barrier on the inner side. Use white painted aluminum jacketing on all outdoor applications operating at 32°F and below. Consult jacketing manufacturer for recommended thicknesses and usage. Typical thickness is 0.016".
- 3.5.2.2 Aluminum jacketing for all fittings, tees, elbows, valves, caps, etc. shall be sectional, factory contoured, or field-fabricated to fit closely around insulation.
- 3.5.2.3 Banding for jacketing shall be 0.02" thick by 1/2" wide stainless steel.
- 3.5.2.4 Aluminum protective jacketing shall not be considered a vapor retarder. See section 3.4 for Vapor Retarder recommendations.
- 3.5.2.5 Neither rivets, screws, staples nor any other fastener

capable of penetrating the underlying vapor retarder shall be used to secure the aluminum jacketing.

## 4. APPLICATION

### 4.1 PIPING - GENERAL

- 4.1.1 Stagger insulation half sections so that butt joints are staggered between top and bottom half sections by 6 to 18 inches on insulation layers that do not have a vapor retarder factory applied to them. On a single layer system, orient longitudinal joints between half sections in the 3 and 9 o'clock position on the pipe. Refer to Figure 2 in Appendix B.
- 4.1.2 Where insulation thickness required is greater than 2 1/2", employ a double layer system. Stagger all longitudinal joints between the inner and outer layers. Install the inner and outer layer longitudinal joints 90° to each other with the inner layer joints in the 12 and 6 o'clock positions and the outer layer joints in the 3 and 9 o'clock positions. All butt joints between the inner and outer layers shall be staggered between 6 and 18 inches. Refer to Figure 3 in Appendix B.
- 4.1.3 Install pre-fabricated insulation fittings on elbows, tees, and valves. Insulation shall be the same thickness at fittings as pipe sections.
- 4.1.4 If a double layer system is required, all fittings shall be double layered. Fittings may be cut to full thickness in lieu of double layered if they are fabricated with shiplap butt ends. Depth of the shiplap shall be cut to the thickness of the inner layer to allow the outer layer to overlap creating a staggered joint. Refer to Figure 4 in Appendix B.
- 4.1.5 Install half-length pipe section half round on bottom of all pipe hanger saddles with a full pipe section half round on the top so as to maintain a staggered joint through the pipe hanger saddle (see Figure 5 in Appendix B). In double layer systems install nested half and full pipe half round sections in bottom of saddle or use a full thickness single layer pipe section with shiplap ends cut to the depth of the inner layer thickness so the outer layer will overlap (see Figure 6 and Figure 7 in Appendix B).
- 4.1.6 Bottom insulation sections in hanger saddles shall be TRYMER 3000, 4000 or 6000 Insulation for resistance to compression on pipe diameters 4" and greater. Depending on the saddle length and span chosen for a specific job, lower density TRYMER insulation such as TRYMER 2000 insulation may be sufficient to be used as saddle insulation. Consult manufacturer for your specific scenario. Saddles shall wrap the insulation in an arc between 120° and 180° depending upon the load.
- 4.1.7 Single layer insulation shall be applied to piping with all joints sealed full depth with joint sealant and spread to uniform thickness so that joints appear tight and uniform. Refer to Figure 8 in Appendix B. In double layer insulation system, inner layer shall not be installed with sealants. In double layer systems, inner and outer layer shall remain independent of each other so as to allow movement between the layers. Refer to Figure 3 in Appendix B.
- 4.1.8 Insulation shall be secured to the pipe with 3/4" wide fiber reinforced tape. Tape shall be applied as per Figure 9 in Appendix B.
- 4.1.9 Insulation shall be secured with fiber reinforced tape on both inner and outer layers of a double layered system except as noted in section 4.1.11.
- 4.1.10 Insulation shall be secured with fiber reinforced tape prior to installation of the vapor retarder material when vapor retarder is field applied.
- 4.1.11 Outer layer or single layer insulation and vapor retarder shall be secured with fiber reinforced tape. Use a 25% circumferential overlap at 12" centers when the vapor retarder is factory applied to insulation. Fiber tape shall be applied to the exterior of the insulation/vapor retarder system. Fiber tape securing outer layer is not required if factory applied SARANEX Vapor Retarder products are used.
- 4.1.12 Contraction/expansion joints in double layer systems shall be installed per Figure 10 in Appendix B or approved alternate design. Contraction/expansion joints in single layer service shall be installed per Figure 11 in Appendix B or approved alternate design. The appropriate designer or engineer must specify the spacing of contraction/expansion joints separately for each system. Recommended expansion/contraction joint spacing is shown in table 1 in Appendix B.
- 4.1.13 All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor retarder must be continuous. All fasteners and bands shall be neatly aligned, and overall work must be of high-quality appearance and workmanship.
- 4.1.14 Vapor stops shall be used on either side of valves frequently removed for servicing, valve stations left exposed, or odd fittings, elbows, tees, etc. where the chance of moisture infiltration is high. Install per detail in Figure 12 in Appendix B or an approved alternate design.
- 4.1.15 SARANEX vapor retarder to be cut to length longitudinally and wrapped around the circumference of the pipe with lap joint facing downward avoiding the placement of the joint at the top or bottom of the pipe. Lap joint to be sealed using SSL tape or liquid adhesive. Butt joints shall be covered with SARANEX Vapor Retarder Tape. Spiral wrap configuration can be used in lieu of the above installation. Spiral wrapping will require adhesive placed on one edge of the SARANEX Film as it is wrapped over the previous layer
- 4.1.16 Elbows and fittings shall be wrapped with SARANEX 520 Vapor Retarder Tape or covered with a mastic type vapor retarder product. SARANEX Tape to be wrapped in a spiral configuration. Where permeance less than 0.02 perms is required, SARANEX 520 tape shall be spiral wrapped with a minimum 50% overlap. If using mastic type vapor retarder at fittings and elbows, form mastic so that fitting covers can be applied true

and tight. Contractor may not install PVC jacket with polyurethane foam fill in lieu of vapor retarder at fittings and elbows without special approval by Owner.

- 4.1.17 On factory applied SARANEX vapor retarder system, lap joint to be sealed with SSL tape. Refer to Figure 13 in Appendix B. Apply the SARANEX Tape around the butt joint with a ¼ circumference overlap. See Figure 14 in Appendix B. For other types of factory applied vapor retarders, consult manufacturer's recommendations on installation.
- 4.1.18 Before jacketing can be installed on a portion of the piping, the vapor retarder system on that portion must be complete and continuous.
- 4.1.19 A pipe coating system may be recommended to minimize the likelihood of pipe corrosion. Consult Appendix A for conditions where pipe coating systems are suggested.

#### **4.2 INDOOR PIPING**

- 4.2.1 This section covers indoor areas including, but not limited to, mechanical rooms, process areas and inhabited areas. Consult applicable codes for areas where flame and smoke code requirements may apply.
- 4.2.2 Allow mastics to dry prior to installing PVC Jacketing.
- 4.2.3 Refer to section 3.5.1 for material specification on indoor PVC Jacketing.
- 4.2.4 Insulation systems on indoor piping, valves and flanges shall all be covered with PVC jacketing.
- 4.2.5 Seal around protrusions, such as valve stems with a full bead of silicone sealant.

#### **4.3 OUTDOOR PIPING**

- 4.3.1 This section covers outdoor areas including, but not limited to, process areas, rooftops and rooftop equipment.
- 4.3.2 XPS Insulation shall be protected from prolonged exposure to UV light and weather upon installation.
- 4.3.3 Outdoors, SARANEX Products shall be covered with a jacketing material within two weeks of installation to eliminate long- term exposure to UV light.
- 4.3.4 Refer to section 3.5.2 for material specification on outdoor aluminum jacketing.
- 4.3.5 Outdoor jacketing overlap shall be a minimum of 2" at butt joints and a minimum of 2" at longitudinal joints. Jacketing shall be caulked before closing and banding and positioned in an orientation to avoid water infiltration.
- 4.3.6 Straight sections of jacketing shall be neatly secured with bands and seals with a maximum spacing of 9" on center. End joints shall be secured with bands and seals centered directly over joint. Do not use screws, staples or other fasteners on lines containing a vapor retarder system.

#### **4.4 TANK, VESSEL EQUIPMENT INSULATION**

- 4.4.1 All insulation materials shall be the same as those used on the pipe associated with the tank, vessel, or equipment.
- 4.4.2 Tank and vessel head segments shall be curved or flat cut to fit in single piece or segments per ASTM C-450. Head segments shall be cut so as to eliminate voids at the head section and in a minimum number of pieces so as to eliminate through joints.

- 4.4.3 Prefabricated flat head sections shall be installed in the same number of layers and thicknesses as the vessel walls. Void area behind the flat head shall be filled with spray applied polyurethane.
- 4.4.4 Curved segments shall be fabricated to fit the contour of the surface in equal size pieces to go around the vessel with a minimum number of through joints. Cutting in the field shall be minimized. All sections shall be tightly butted and free of voids and gaps. Refer to Figure 15 in Appendix B.
- 4.4.5 Vertical vessels greater than 4 feet in diameter require an insulation support ring welded or bolted around the bottom of the tank to prevent the shell insulation from sliding down.
- 4.4.6 Seal all outer layer and single layer butt joints with joint sealer. Refer to section 3.3.
- 4.4.7 In double layer applications, the horizontal and vertical joints of the inner and outer layer curved segments shall be staggered (see Figure 15 in Appendix B).
- 4.4.8 The top of the outer layer of wall insulation in a double layer system shall be held below the inner layer top a minimum of the insulation thickness. The tank head insulation layers shall be cut so as to meet the staggered joint. Refer to Figure 15 in Appendix B.
- 4.4.9 Secure the shell insulation with stainless steel bands on 12-inch centers.
- 4.4.10 Install SARANEX 540 or 560 Vapor Retarder Film. Tightly wrap the vessel or equipment insulation circumferentially with SARANEX Film. Overlap the seams by a minimum of 2 inches. Seal the overlapped seams with SARANEX Vapor Retarder Tape. On vertical vessels apply the SARANEX Film starting with the bottom course and work upwards. Each course should overlap on top of the one below it thus providing a joint that will naturally shed water.
- 4.4.11 The vapor retarder on curved head sections shall be mastic/fab/mastic or approved alternate. Flat head sections can be covered with SARANEX 540 or 560 film. Lap joints shall be covered with SARANEX Vapor Retarder Tape.
- 4.4.12 Legs and appendages attached directly to the shell shall be insulated out from the vessel head or wall four times the insulation thickness and the insulation termination sealed with a vapor stop.
- 4.4.13 Indoor tanks, vessels, and equipment shall be covered with PVC jacketing per section 3.5.1. On outdoor equipment use aluminum jacketing per section 3.5.2. Rivets and screws shall not be used to attach jacketing on systems using a vapor retarder.

### **5. APPENDICES**

#### **5.1 APPENDIX A: CORROSION RESISTANT METAL COATINGS**

##### **5.1.1 GENERAL NOTE**

Corrosion of metal pipe, vessels, and equipment under insulation, while not typically caused by the insulation, is still a significant issue that must be considered



during the design of any mechanical insulation system. The propensity for corrosion is dependent on many factors including the ambient environment and the operating temperature of the metal. The recommendations below represent the general practice in the industry but are not meant to take the place of proper system design and specification by a qualified design engineer familiar with this type of construction. We recommend that the owner consult such an engineer and have them work closely with the fabricator, the contractor, and Dow to help insure a properly designed, installed, and long-lasting insulation system free of corrosion.

### 5.1.2 SPECIFIC RECOMMENDATIONS

5.1.2.1 Stainless Steel All 300 series stainless steel shall be coated with an epoxy primer at 5 mil thickness and an epoxy finish coat at 5 mil thickness if operating in a temperature range between 140°F and 300°F or if in a cycling temperature service where the service temperature is between 140° and 300°F for more than 20% of the time. Consult a coating manufacturer for appropriate coating materials and application methods based on the operating temperature range of the equipment.

5.1.2.2 Carbon Steel All carbon steel operating at a service temperature between 32°F and 300°F or in cycling temperature service where the service temperature is between 32°F and 300°F for more than 20% of the time shall be at a minimum primer coated with an epoxy coating. Consult a coating manufacturer for appropriate coating materials and application methods for the operating temperature range of the equipment.

## 5.2 APPENDIX B: DETAILS

The following details are referenced in the text of this guideline by their Figure numbers. The diagrams included in this section are representative of details used within the industry. However, they are not intended to display the only accepted method of installation but to serve more as an example of commonly used and acceptable practices.

**TABLE 1: EXPANSION/CONTRACTION JOINTS RECOMMENDED**

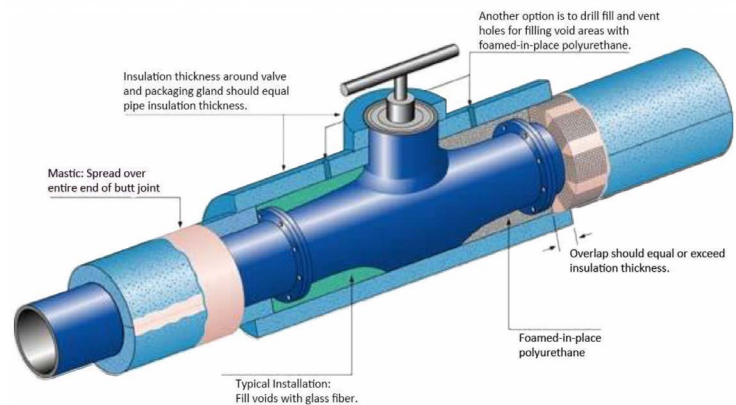
Ambient Temp °F	Service Temperature °F											
	-70	-65	-55	-45	-35	-25	-15	-5	5	15	25	35
-10												
0												
10												
20												
30												
40												
50												
60												
70												
80												
90												
100												
110												

\*\*\* 1 joint every 150' for pipe lengths over 200'

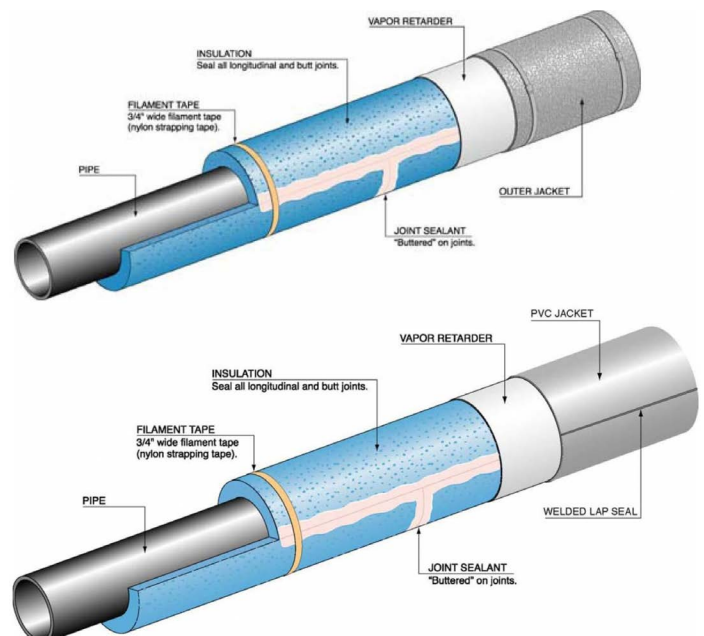
1 joint every 50' for pipe lengths 50-100'

1 joint for pipe lengths below 50'

**FIGURE 1: VALVE INSULATION DETAIL (Including Optional Filling of Voids)**

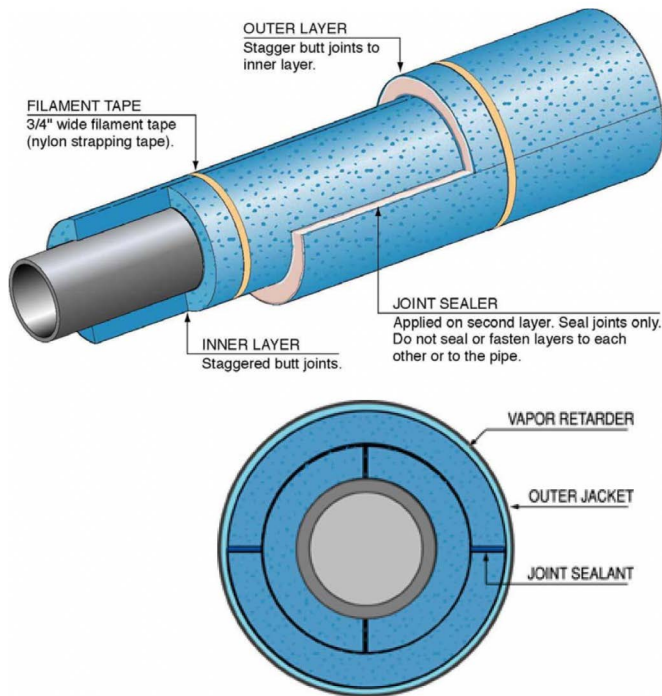


**FIGURE 2: SINGLE LAYER INSULATION WITH VAPOR RETARDER AND JACKET**

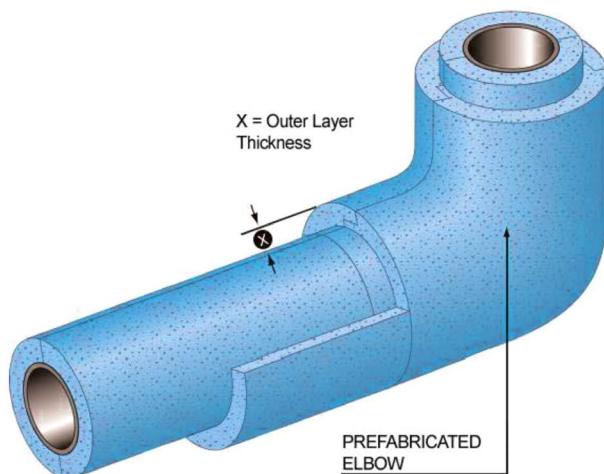


### Detail Notes:

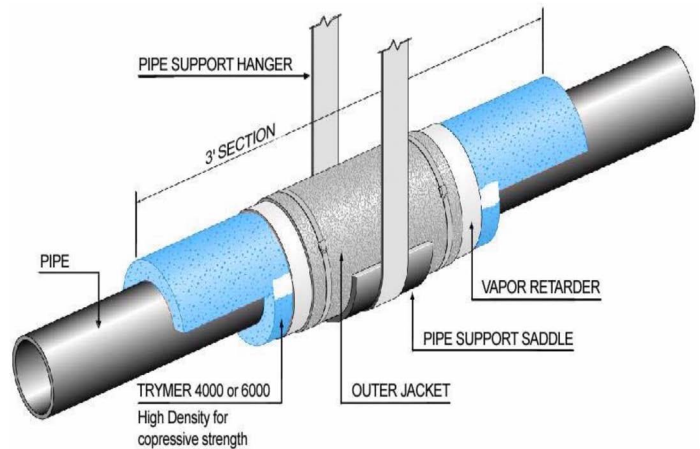
- Stagger bottom half round segments from top segments as shown if vapor retarder is field applied.
- Use thin coat of sealant over whole joint depth. Butter excess down face of joint as pictured.

**FIGURE 3: DOUBLE LAYERED INSULATION SYSTEM****Detail Notes:**

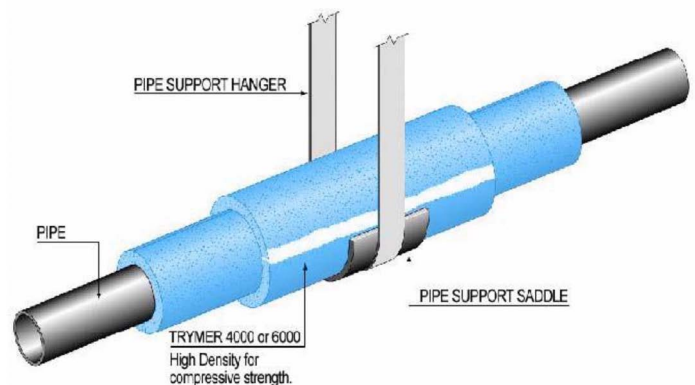
- Inner Layer longitudinal joints at 12 and 6 O'clock. Outer layer joints at 3 and 9 O'clock.
- Stagger half round segments on each layer and between the two layers as shown above.
- Use thin coat of sealant over whole joint depth. Butter excess down the face of the joint. Use sealant on outer layer only.

**FIGURE 4: FULL THICKNESS SHIPLAP ELBOW FITTING****Detail Notes:**

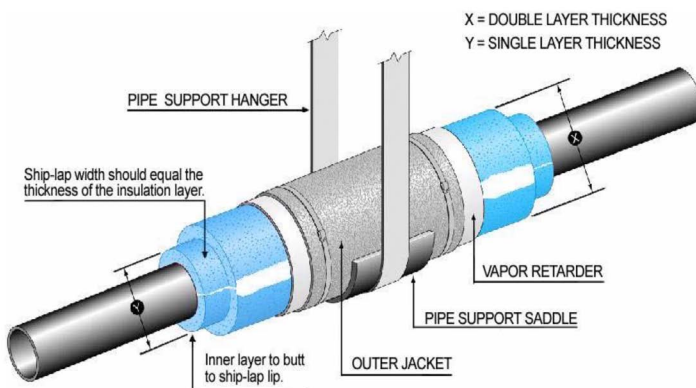
- Shiplap end cut to thickness X to accommodate double layer pipe insulation.
- Use in lieu of double layered fittings.
- Wrap elbow with SARANEX 520 vapor retarder tape.

**FIGURE 5: SINGLE LAYER INSULATION SYSTEM THROUGH PIPE HANGER SUPPORT****Detail Notes:**

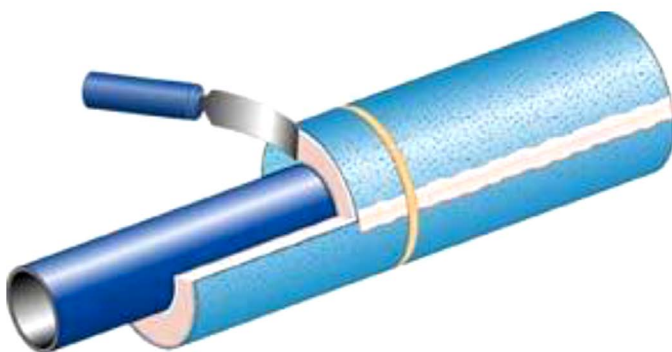
- On smaller pipe diameters (3" or less) use XPS Insulation on bottom of saddle. For 4" pipe and up use higher density TRYMER Insulation on bottom of saddle for additional compressive strength.
- Vapor Retarder and Jacketing to be installed in continuous fashion through the pipe support.

**FIGURE 6: DOUBLE LAYER INSULATION SYSTEM THROUGH PIPE HANGER SUPPORT****Detail Notes:**

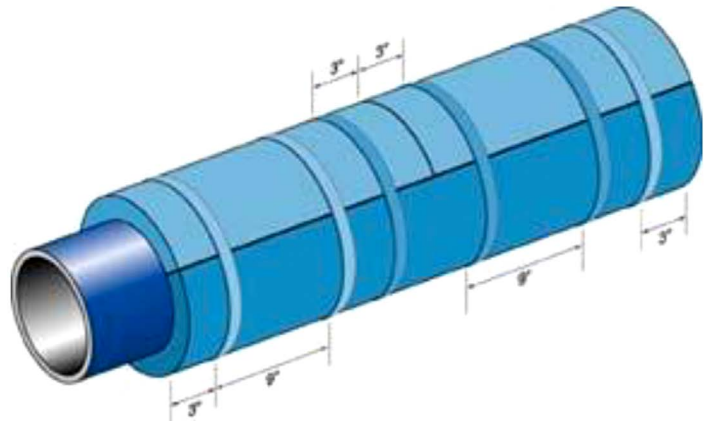
- On smaller pipe diameters (3" or less) use XPS Insulation on bottom of saddle. For 4" pipe and up use higher density TRYMER Insulation on bottom of saddle for additional compressive strength.
- Install shorter section on outside layer.
- Vapor Retarder and Jacketing to be installed in continuous fashion through the pipe support.

**FIGURE 7: FULL THICKNESS INSULATION SECTION IN DOUBLE LAYERED SYSTEM AT PIPE HANGER SUPPORT****Detail Notes:**

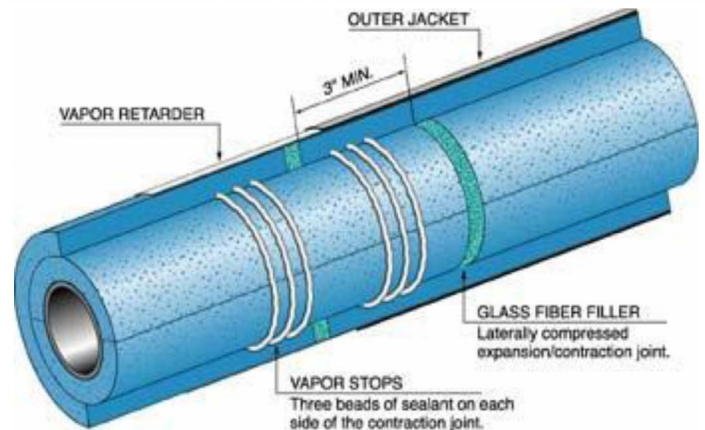
- On smaller pipe diameters (3" or less) use XPS Pipe Billet Insulation on bottom of saddle. For 4" pipe and up use higher density TRYMER Insulation on bottom of saddle for additional compressive strength.
- Width of shiplap ends shall be equal to the thickness of a single insulation layer.
- Butt inner layer to shiplap end. Outer layer shall be staggered by width of shiplap end.
- Vapor Retarder and Jacketing to be installed in continuous fashion through the pipe support.

**FIGURE 8: SEALANT APPLICATION TECHNIQUE****Detail Notes:**

- Use thin coat of sealant over whole joint depth. Butter excess down the face of the joint as shown. Use sealant on outer layer only.

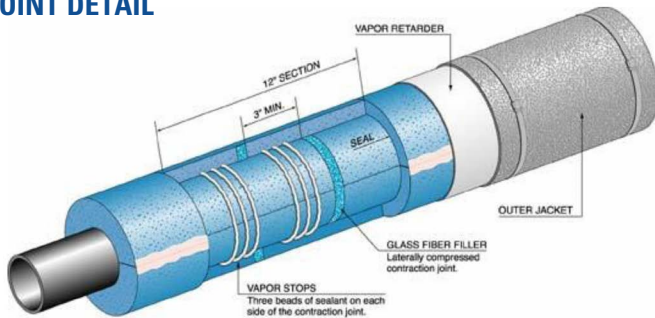
**FIGURE 9: TAPING PATTERN****Detail Notes:**

- Use two wraps of tape to insure adequate bond.
- Use nylon or glass filament type tape 3/4" wide.

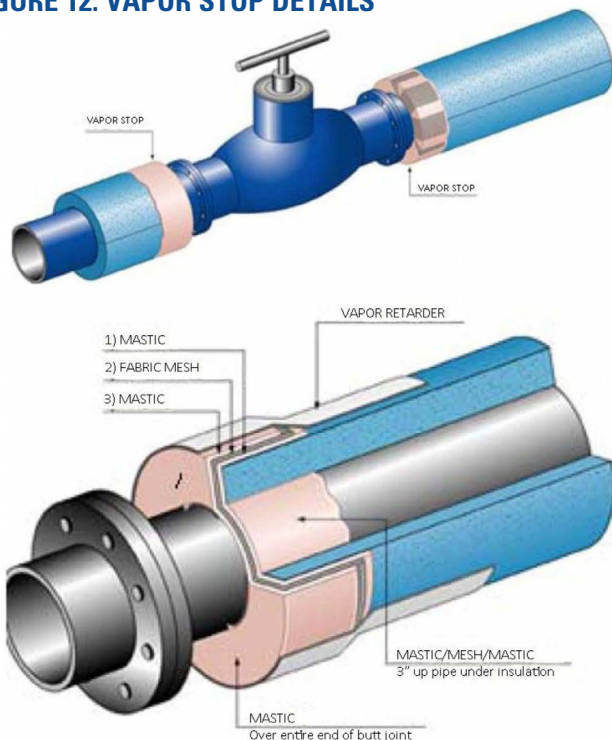
**FIGURE 10: DOUBLE LAYER EXPANSION/CONTRACTION JOINT DETAIL****Detail Notes:**

- Allow sealant beads to cure prior to installation of outer layer.
- Position outer layer packed glass fiber between sealant dams on inner layer as shown above.
- After glass fiber in contraction joint is installed, insulation sections on either side of contraction joint shall be forced together as tightly as possible.

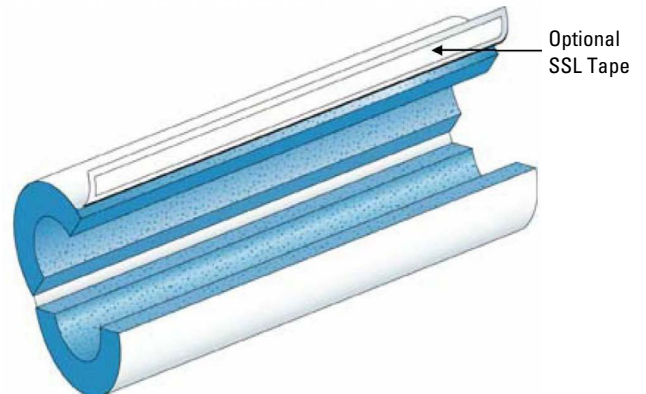


**FIGURE 11: SINGLE LAYER EXPANSION/CONTRACTION JOINT DETAIL****Detail Notes:**

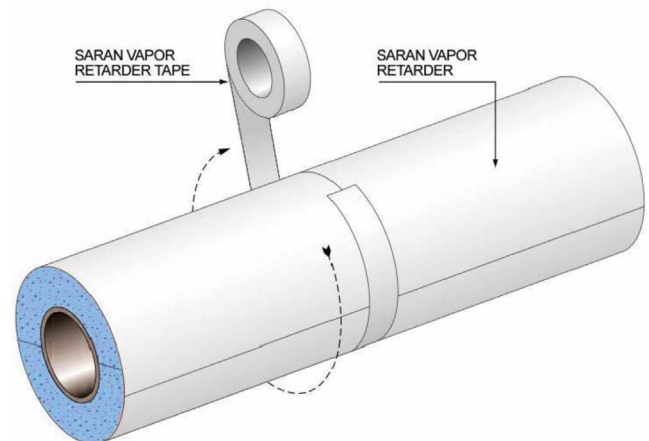
- For use in single layer refrigeration applications below 32°F.
- Allow sealant beads to cure prior to installation of outer layer.
- Position outer layer packed glass fiber between sealant dams on inner layer as shown above.
- After glass fiber in contraction joint is installed, insulation sections on either side of contraction joint shall be forced together as tightly as possible.
- Mastic should be selected based on the service temperature of the system.
- Mastic shall be sealed to the pipe face and lapped back over the top of the vapor retarder if fitting is left exposed.

**FIGURE 12: VAPOR STOP DETAILS****Detail Notes:**

- Mastic should be selected based on the service temperature of the system.
- Mastic shall be sealed to the pipe face and lapped back over the top of the vapor retarder if fitting is left exposed.

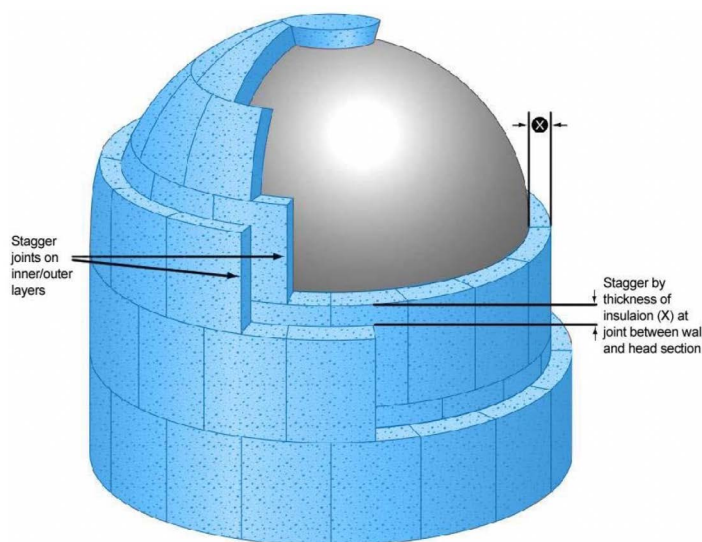
**FIGURE 13: DETAIL OF FACTORY APPLIED VAPOR RETARDER****Detail Notes:**

- Vapor Barrier can be installed using SSL tape as shown above or using liquid adhesives.
- Butt joints to be covered a minimum of 1.5" on each side of joint by SARANEX Tape or butt strip.

**FIGURE 14: FACTORY APPLIED SARANEX VAPOR RETARDER FILM AND SARANEX TAPE****Detail Notes:**

- Lap seal on SARANEX Film to be SSL Tape or liquid adhesive per Installation Guide on SARANEX Film.
- When operating temperature is  $\leq 32^{\circ}\text{F}$  or when a permeance of 0.02 perms or better is required, butt joints shall be wrapped with either two layers of SARANEX 520 Vapor Retarder Tape or a single layer of SARANEX 560 Tape. When operating temperature is  $> 32^{\circ}\text{F}$ , butt joints shall be wrapped with a single layer of SARANEX 520 Tape.
- SARANEX Tape used at butt joints shall be 3 inches wide.
- Wrap tape around butt joint a minimum of 1.25 times the circumference.



**FIGURE 15: TANK HEAD INSULATION DETAIL****Detail Notes:**

- In multiple layer systems, each layer shall be installed so that the horizontal and vertical joints in that layer are staggered from the corresponding joints in the preceding layer by half the height or width of a full section.
- At joint between wall and head section, the outer layer shall be staggered below the inner layer by the thickness of a single layer.
- Where mastics or sealants are required to bond the insulation sections to the tank head consult the manufacturer's recommendations on service and application temperatures.

**5.3 APPENDIX C: THICKNESS TABLES**

The following tables primarily show the insulation thickness necessary to prevent condensation on the outer surface of the insulation system jacketing. In a few cases, the tables also include the insulation thickness necessary to limit the heat gain to a specific value (usually 8 btu/hr-ft of outer jacketing surface) and are noted as such. These thickness recommendations are solely based on various design conditions that are shown with each table. A number of assumptions are also made, including proper system design and installation. There may be additional factors the tables do not address that could influence the end results. These thickness tables are not meant to replace a proper system design and specification by a qualified design engineer familiar with specific ambient design parameters for a given locality. We recommend that you consult such an engineer and have them work closely with the contractor, and Dow to help insure a properly designed, installed, and long-lasting insulation system. Thickness calculations are performed using the 3E Plus software program that uses heat flow algorithms based on ASTM C-680-95. The required insulation thicknesses do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor.

**TABLE 1: XPS PIB FOR AMMONIA REFRIGERATION INDOORS**

NPS (in)	Service Temperature (°F)							
	-100	-80	-60	-40	-20	0	20	40
0.5	2.5	2.5	2.5	2	2	1.5	1.5	1
0.75	2.5	2.5	2.5	2.5	2	2	1.5	1.5
1	3	2.5	2.5	2.5	2	2	1.5	1
1.75	3	3	3	2.5	2.5	2	1.5	1.5
1.5	3	2.5	2.5	2	2	2	1.5	1.5
2	3.5	3	3	2.5	2.5	2	1.5	1.5
2.5	3	3	2.5	2.5	2	2	1.5	1.5
3	3.5	3.5	3	3	2.5	2	2	1.5
4	4	3.5	3	3	2.5	2.5	2	1.5
5	4	3.5	3.5	3	2.5	2.5	2	1.5
6	4	3.5	3.5	3	3	2.5	2	1.5
8	4	4	3.5	3	3	2.5	2	1.5
10	4.5	4	3.5	3.5	3	2.5	2	1.5
12	4.5	4	4	3.5	3	2.5	2	1.5
14	4.5	4.5	4	3.5	3	2.5	2	1.5
16	5	4.5	4	3.5	3	2.5	2	1.5
18	5	4.5	4	3.5	3	3	2	1.5
20	5	4.5	4	3.5	3.5	3	2.5	1.5
Side	6	5.5	5	4.5	3.5	3	2.5	2
Top	6	5.5	5	4.5	3.5	3	2.5	2
Bttm	6	5.5	5	4.5	3.5	3	2.5	2

Ambient temp: 90°F

Ambient Relative Humidity: 80%

Dewpoint: 83°F

Outer surface: Saran or PVC ( $\epsilon = 0.90$ )

Wind Velocity: 0 mph

Geometry: Horizontal Pipe

Insulation thickness in inches necessary to prevent condensation or limit heat gain to 8 BTU/hr-sq ft, whichever is greater.

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.

**TABLE 2: XPS PIB FOR AMMONIA REFRIGERATION  
OUTDOORS**

NPS (in)	Service Temperature (°F)							
	-100	-80	-60	-40	-20	0	20	40
0.5	3.5	3.5	3	2.5	2.5	2.5	2	1.5
0.75	4	3.5	3.5	3	2.5	2.5	2	2
1	4.5	4	3.5	3.5	3	2.5	2	2
1.75	4.5	4.5	4	3.5	3.5	3	2.5	2
1.5	4.5	4	4	3.5	3	2.5	2	2
2	5	4.5	4	4	3.5	3	2.5	2
2.5	5	4.5	4	4	3.5	3	2.5	2
3	5.5	5	5	4.5	4	3.5	3	2.5
4	6	5.5	5	4.5	4	3.5	3	2.5
5	6	6	5.5	5	4.5	4	3	2.5
6	6.5	6	5.5	5	4.5	4	3.5	2.5
8	7	6.5	6	5.5	5	4	3.5	2.5
10	7.5	7	6.5	6	5	4.5	3.5	3
12	7.5	7	6.5	6	5.5	4.5	4	3
14	8	7.5	7	6	5.5	5	4	3
16	8	7.5	7	6.5	5.5	5	4	3.5
18	8.5	7.5	7	6.5	6	5	4	3.5
20	8.5	8	7	6.5	6	5	4.5	3.5
Side	9	8.5	7.5	6.5	6	5	4	3
Top	7.5	7	6.5	5.5	5	4	3.5	2.5
Bttm	12	11	10	9	8	6.5	5.5	4

Ambient temp: 100°F

Ambient Relative Humidity: 90%

Dewpoint: 96.5°F

Outer surface: Metal ( $\epsilon = 0.40$ )

Wind Velocity: 7.5 mph

Geometry: Horizontal Pipe

Insulation thickness in inches necessary to prevent condensation or limit heat gain to 8 BTU/hr-sq ft, whichever is greater.

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.

**TABLE 3: INSULATION THICKNESS NECESSARY TO PREVENT CONDENSATION**

XPS PIB Thickness Table Indoors. High Humidity. Narrow Temp Range.

Ambient Temp = 70°F

Ambient Relative Humidity = 90%

Dew point = 67.0°F

Outer surface = Saran, PVC ( $\epsilon = 0.90$ )

Wind Velocity = 0 mph

Geometry = Horizontal Pipe

NPS (in)	Service Temperature (F)																		
	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35
0.5	3.5	3	3	3	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2	2	1.5	1.5	1.5
0.75	3.5	3.5	3.5	3	3	3	3	3	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2	1.5	1.5
1	4	4	3.5	3.5	3.5	3.5	3	3	3	3	2.5	2.5	2.5	2.5	2	2	2	1.5	1.5
1.25	4	4	4	4	4	3.5	3.5	3.5	3.5	3	3	3	2.5	2.5	2.5	2.5	2	1.5	1.5
1.5	4	4	4	4	4	3.5	3.5	3.5	3.5	3	3	3	2.5	2.5	2.5	2.5	2	2	1.5
2	4.5	4.5	4	4	4	4	3.5	3.5	3.5	3.5	3	3	3	2.5	2.5	2.5	2	2	2
2.5	4.5	4.5	4	4	4	4	3.5	3.5	3.5	3.5	3	3	3	2.5	2.5	2.5	2	2	2
3	5	5	4.5	4.5	4.5	4	4	4	3.5	3.5	3.5	3.5	3	3	2.5	2.5	2.5	2	2
4	5	5	5	4.5	4.5	4.5	4.5	4	4	4	3.5	3.5	3	3	3	2.5	2.5	2	2
5	5.5	5	5	5	4.5	4.5	4.5	4	4	4	4	3.5	3.5	3	3	3	2.5	2.5	2
6	5.5	5.5	5.5	5	5	5	4.5	4.5	4	4	4	3.5	3.5	3.5	3	3	2.5	2.5	2
8	6	6	5.5	5.5	5	5	5	4.5	4.5	4	4	4	3.5	3.5	3	3	2.5	2.5	2
10	6.5	6	6	5.5	5.5	5.5	5	5	4.5	4.5	4.5	4	4	3.5	3.5	3	3	2.5	2
12	6.5	6.5	6	6	5.5	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3.5	3	3	2.5	2.5
14	6.5	6.5	6.5	6	6	5.5	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3.5	3	2.5	2.5
16	7	6.5	6.5	6.5	6	6	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3.5	3	3	2.5
18	7	7	6.5	6.5	6	6	5.5	5.5	5	5	5	4.5	4	4	3.5	3.5	3	3	2.5
20	7	7	6.5	6.5	6.5	6	6	5.5	5.5	5	5	4.5	4.5	4	3.5	3.5	3	3	2.5
24	7.5	7	7	6.5	6.5	6	6	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3	3	2.5
30	7.5	7.5	7	7	6.5	6.5	6	6	5.5	5.5	5	5	4.5	4	4	3.5	3.5	3	2.5
36	7.5	7.5	7	7	6.5	6.5	6	6	5.5	5.5	5	5	4.5	4	4	3.5	3.5	3	2.5
48	8	7.5	7.5	7	7	6.5	6.5	6	6	5.5	5	5	4.5	4.5	4	3.5	3.5	3	2.5

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.

**TABLE 4: INSULATION THICKNESS NECESSARY TO PREVENT CONDENSATION**

XPS PIB Thickness Table for Harsh Indoor Conditions

Ambient Temp = 90°F

Ambient Relative Humidity = 90%

Dew point = 86.6°F

Outer surface = Saran, PVC, ASSJ, or mastic ( $\epsilon = 0.90$ )

Wind Velocity = 0 mph

Geometry = Horizontal Pipe

NPS (in)	Service Temperature (F)																		
	300	280	260	240	220	200	180	160	140	120	100	80	60	40	20	0	20	40	60
0.5	5.5	5.5	5.5	5.5	5	5	5	4.5	4.5	4	4	3.5	3.5	3	2.5	2.5	2	1.5	1
0.75	6	6	6	5.5	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3	3	2.5	2.5	2	1.5
1	6.5	6.5	6	5	6	6	5.5	5.5	5	5	4.5	4.5	4	3.5	3	2.5	2.5	2	1
1.25	7	7	6.5	6.5	6.5	6	6	6	5.5	5.5	5	4.5	4.5	4	3.5	3	2.5	2	1.5
1.5	7	6.5	6.5	6.5	6	6	6	5.5	5.5	5	4.5	4.5	4	3.5	3	3	2.5	2	1.5
2	7.5	7.5	7	7	7	6.5	6.5	6	6	5.5	5	5	4.5	4	3.5	3	2.5	2	1.5
2.5	7.5	7.5	7	7	7	6.5	6.5	6	6	5.5	5	5	4.5	4	3.5	3	2.5	2	1.5
3	8	8	8	7.5	7.5	7.5	7	6.5	6.5	6	5.5	5.5	5	4.5	4	3.5	3	2.5	1.5
4	8.5	8.5	8.5	8	8	7.5	7.5	7	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	1.5
5	9	9	9	8.5	8.5	8	8	7.5	7	7	6.5	6	5.5	5	4.5	4	3	2.5	1.5
6	9.5	9.5	9.5	9	9	8.5	8	8	7.5	7	6.5	6	5.5	5	4.5	4	3.5	2.5	1.5
8	10	10	10	9.5	9.5	9	8.5	8.5	8	7.5	7	6.5	6	5.5	5	4	3.5	2.5	1.5
10	11	10.5	10.5	10	10	9.5	9	9	8.5	8	7.5	7	6.5	5.5	5	4.5	3.5	2.5	1.5
12	11	11	10.5	10.5	10	10	9.5	9	8.5	8	7.5	7	6.5	6	5	4.5	3.5	2.5	1.5
14	11.5	11.5	11	11	10.5	10	10	9.5	9	8.5	8	7.5	7	6	5.5	4.5	4	3	2
16	12	11.5	11.5	11	11	10.5	10	9.5	9	8.5	8	7.5	7	6.5	5.5	4.5	4	3	2
18	12	12	11.5	11.5	11	10.5	10.5	10	9.5	9	8.5	7.5	7	6.5	5.5	5	4	3	2
20	12.5	12	12	11.5	11.5	11	10.5	10	9.5	9	8.5	8	7	6.5	5.5	5	4	3	2
24	13	12.5	12.5	12	11.5	11.5	11	10.5	10	9.5	8.5	8	7.5	6.5	5	5	4	3	2
30	13.5	13	13	12.5	12	11.5	11	11	10	9.5	9	8.5	7.5	7	5	5	4	3	2
36	13.5	13.5	13	13	12.5	12	11.5	11	10.5	10	9	8.5	8	7	5	5	4	3	2
48	14.5	14	13.5	13.5	13	12.5	12	11.5	11	10.5	9.5	9	8	7	6.5	5.5	4.5	3	2

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.



**TABLE 5: INSULATION THICKNESS NECESSARY TO PREVENT CONDENSATION**

XPS PIB Thickness Table for Very Harsh Outdoor Installations

Ambient Temp = 90°F

Ambient Relative Humidity = 90%

Dew point = 86.6°F

Outer surface = Metal ( $\epsilon = 0.40$ )

Wind Velocity = 0 mph

Geometry = Horizontal Pipe

NPS (in)	Service Temperature (F)																		
	-300	-280	-260	-240	-220	-200	-180	-160	-140	-120	-100	-80	-60	-40	-20	0	20	40	60
0.5	5.5	5.5	5.5	5	5	5	4.5	4.5	4.5	4	4	3.5	3	3	2.5	2.5	2	1.5	1
0.75	6	6	6	5.5	5.5	5.5	5	5	4.5	4.5	4	4	3.5	3	2.5	2.5	2	1.5	1
1	6.5	6.5	6	6	6	5.5	5.5	5.5	5	4.5	4.5	4	4	3.5	3	2.5	2	1.5	1
1.25	7	7	6.5	6.5	6.5	6	6	6	5.5	5	5	4.5	4	4	3.5	3	2.5	1.5	1.5
1.5	7	6.5	6.5	6.5	6	6	5.5	5.5	5.5	5	4.5	4.5	4	3.5	3	2.5	2	2	1.5
2	7.5	7.5	7	7	7	6.5	6.5	6	6	5.5	5	5	4.5	4	3.5	3	2.5	2	1.5
2.5	7.5	7.5	7.5	7	7	6.5	6.5	6	6	5.5	5	5	4.5	4	3.5	3	2.5	1.5	1.5
3	8.5	8.5	8	8	7.5	7.5	7	7	6.5	6	5.5	5.5	5	4.5	4	3.5	3	2	1.5
4	9	9	8.5	8.5	8	8	7.5	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	1.5
5	9.5	9.5	9	9	8.5	8.5	8	7.5	7.5	7	6.5	6	5.5	5	4.5	4	3	2.5	1.5
6	10	10	9.5	9.5	9	9	8.5	8	7.5	7.5	7	6.5	5.5	5	4.5	4	3.5	2.5	1.5
8	10.5	10.5	10	10	9.5	9.5	9	8.5	8.5	8	7.5	6.5	6	5.5	5	4	3.5	2.5	1.5
10	11	11	10.5	10.5	10	10	9.5	9	8.5	8	7.5	7	6.5	6	5	4.5	3.5	2.5	1.5
12	11.5	11.5	11	11	10.5	10	10	9.5	9	8.5	8	7.5	7	6	5.5	4.5	3.5	3	1.5
14	12	11.5	11.5	11	11	10.5	10	10	9.5	9	8.5	7.5	7	6.5	5.5	5	4	3	2
16	12	12	12	11.5	11	11	10.5	10	9.5	9	8.5	8	7	6.5	5.5	5	4	3	2
18	12.5	12.5	12	12	11.5	11	10.5	10	9.5	9	8.5	8	7.5	6.5	6	5	4	3	2
20	13	12.5	12.5	12	11.5	11.5	11	10.5	10	9.5	9	8	7.5	6.5	6	5	4	3	2
24	13	13	12.5	12.5	12	11.5	11	11	10	9.5	9	8.5	7.5	7	6	5	4	3	2
30	14	13.5	13	13	12.5	12	11.5	11	10.5	10	9.5	8.5	8	7	6	5.5	4.5	3	2
36	14	14	13.5	13.5	13	12.5	12	11.5	11	10.5	9.5	9	8	7	6.5	5.5	4.5	3.5	2

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.

**TABLE 5: INSULATION THICKNESS NECESSARY TO PREVENT CONDENSATION OR LIMIT HEAT GAIN TO 8 BTU/HR-SQ FT, WHICHEVER IS GREATER**

XPS PIB Thickness Table for Inside a Cold Storage Room

Ambient Temp = 40°F

Ambient Relative Humidity = 90%

Dew point = 37.3°F

Outer surface = PVC or Saran ( $\epsilon = 0.90$ )

Wind Velocity = 0 mph

Geometry = Horizontal Pipe

NPS (in)	Service Temperature (F)																
	-300	-280	-260	-240	-220	-200	-180	-160	-140	-120	-100	-80	-60	-40	-20	0	10
0.5	7	6.5	6.5	6.5	6	6	5.5	5.5	5	4.5	4	3.5	3	2.5	2.5	2	1.5
0.75	7.5	7	7	6.5	6.5	6	6	5.5	5.5	5	4.5	4	3.5	3	2.5	2	1.5
1	8	7.5	7.5	7.5	7	6.5	6.5	6	6	5.5	5	4.5	4	3.5	2.5	2	1.5
1.25	8.5	8.5	8	8	7.5	7.5	7	6.5	6	6	5.5	5	4.5	3.5	3	2	1.5
1.5	8.5	8	8	7.5	7.5	7	7	6.5	6	5.5	5	4.5	4	3.5	2.5	2	2
2	9	9	8.5	8.5	8	8	7.5	7	6.5	6	5.5	5	4.5	4	3	2	2
2.5	9.5	9	9	8.5	8	8	7.5	7	6.5	6	5.5	5	4.5	3.5	3	2	1.5
3	10	10	9.5	9.5	9	8.5	8	7.5	7.5	6.5	6	5.5	5	4	3.5	2.5	2
4	10.5	10.5	10	10	9.5	9	8.5	8	7.5	7	6.5	6	5	4.5	3.5	2.5	2
5	11	11	10.5	10.5	10	9.5	9	8.5	8	7.5	7	6	5.5	4.5	3.5	2.5	2
6	11.5	11.5	11	11	10.5	10	9.5	9	8.5	8	7	6.5	5.5	4.5	4	3	2
8	12.5	12	12	11.5	11	10.5	10	9.5	9	8.5	7.5	7	6	5	4	3	2.5
10	13	13	12.5	12	11.5	11	10.5	10	9.5	9	8	7	6.5	5.5	4	3	2.5
12	13.5	13.5	13	12.5	12	11.5	11	10.5	10	9	8.5	7.5	6.5	5.5	4.5	3	2.5
14	14	13.5	13.5	13	12.5	12	11.5	11	10	9.5	8.5	7.5	7	5.5	4.5	3.5	2.5
16	14.5	14	13.5	13.5	13	12.5	12	11	10.5	9.5	9	8	7	6	4.5	3.5	2.5
18	14.5	14.5	14	13.5	13	12.5	12	11.5	10.5	10	9	8	7	6	4.5	3.5	2.5
20	15	14.5	14.5	14	13.5	13	12.5	11.5	11	10	9	8	7	6	5	3.5	2.5
24	15.5	15	15	14.5	14	13.5	12.5	12	11	10.5	9.5	8.5	7.5	6	5	3.5	2.5

This table is based on ASTM C 680-95 heat transfer algorithms. The suggested insulation thickness values assume proper system design and installation, do not include a safety factor, and are applicable only for the specified scenario. JM recommends that the user consult a qualified design engineer familiar with this type of construction for proper system design and specification.



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