

TRYMER® POLYISOCYANURATE (PIR) LNG Systems Guide

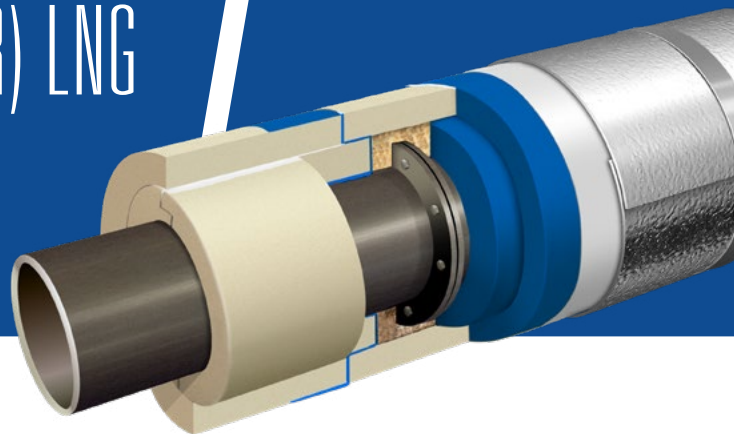


Table of Contents

Section 1 – Scope	3
Section 2 – General	3
Section 3 – Applicable Codes & Standards	3
Section 4 – Materials of Construction	4
4.1 Materials for Piping, Equipment, Fittings, and Valves.....	4
4.1.1 Insulation.....	4
4.1.2 Vapor Retarder	4
4.1.3 Metal Jacketing	4
4.2 Adhesives, Joint Sealers, and Mastics	5
4.3 Contraction/Expansion Joints.....	6
4.4 Vapor Stops	6
4.5 Protrusions.....	6
Section 5 – Application	7
5.1 Piping General.....	7
5.2 Outdoor Piping.....	9
5.3 Tank, Vessel and Equipment Insulation	9
5.4 Cryogenic Pipe Supports.....	10
5.5 Valves and Flanges.....	11
Section 6 – Inspection	11
Section 7 – Appendices	11

SECTION 1 – SCOPE

- 1.1 This guide covers the installation of a complete thermal insulation system on Liquefied Natural Gas (LNG) piping systems, tanks, vessels and equipment surfaces (service temperature range -320°F to -70°F (-196°C to -57°C)).
- 1.2 Product data sheets and other Johns Manville (JM) literature are referenced throughout this guideline. Visit www.jm.com for the latest version of these documents.
- 1.3 The information contained in this guide and referenced JM documents are current as of December 2022. This guide is subject to revision without notice. Contact Johns Manville Customer Information Group at 1-800-231-1024 or your local JM Representative for the most recent version of this guide or other referenced JM literature.
- 1.4 Due to the variations in service conditions and use, this guide may not be pertinent for every application. A design or specifying engineer should create specifications tailored to specific applications, local conditions, budgets, environments, owner’s needs, and/or the desired service life of the system. This guide should not be used in place of specifications.
- 1.5 This guide is not suitable and should not be used for the purpose of installing another manufacturer’s products. While supplemental insulation products may be referenced in this guide, JM recommends consulting with the manufacturers of these products for proper installation and handling.
- 1.6 This guideline is offered as a guide for the purpose described herein. No warranty of procedures, either expressed or implied is intended. All express or implied warranties, including the warranty of merchantability or fitness for a particular purpose are disclaimed.
- 1.7 The purpose of this installation guideline is to serve as a reference document for engineers and designers; this is not a step-by-step guide.
- 1.8 Johns Manville’s terms and conditions, which can be found on www.jm.com, apply to the sale of JM’s products.

SECTION 2 – GENERAL

- 2.1 Ensure all piping and equipment surfaces are free of foreign substances and surface moisture or frost prior to applying the insulation.
- 2.2 All insulation material should be delivered from fabricator/distributor to the project site in original, unbroken, factory packaging labeled with product designation and thickness. The shipping package should not be airtight. Materials should be shipped from the fabricator/distributor to the installation location in weather-tight transportation. Insulation materials delivered to the job site should be protected from moisture and weather during storage and installation. Additionally, protect the insulation material from sunlight to avoid exposure to UV light.
- 2.3 All testing of piping systems and equipment items is completed prior to installing the insulation system.
- 2.4 For insulation thickness calculations, please call JM at 1-800-654-3103, Option 3.

SECTION 3 – APPLICABLE CODES & STANDARDS

- | | |
|------------|---|
| ASTM A240 | Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Vessels and for General Applications |
| ASTM B209 | Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate |
| ASTM C272 | Standard Test Method for Water Absorption of Core Materials for Sandwich Constructions |
| ASTM C450 | Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping and Vessel Lagging |
| ASTM C518 | Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus |
| ASTM C585 | Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Piping and Tubing |
| ASTM C591 | Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation |
| ASTM C680 | Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperature of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs |
| ASTM C692 | Standard Test Method for Evaluating the Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel |
| ASTM C755 | Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation |
| ASTM C795 | Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel |
| ASTM C871 | Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate and Sodium Ions |
| ASTM C1136 | Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation |
| ASTM C1729 | Standard Specification for Aluminum Jacketing for Insulation |
| ASTM C1767 | Standard Specification for Stainless Steel Jacketing for Insulation |
| ASTM D1622 | Standard Test Method for Apparent Density of Rigid Cellular Plastics |
| ASTM D374 | Standard Test Methods for Thickness of Solid Electrical Insulation |
| ASTM E84 | Standard Test Method for Surface Burning Characteristics of Building Materials |
| ASMT E96 | Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials |

SECTION 4 – MATERIALS OF CONSTRUCTION

4.1 Materials for Piping, Equipment, Fittings, and Valves

4.1.1 Insulation

4.1.1.1

- A. Manufacturer: Johns Manville
- B. Product: Trymer® 2500 PIR, compliant with ASTM C591, Grade 2, Type II
- C. Material Physical Properties:
 - a) Rigid, closed-cell, preformed polyisocyanurate insulation for pipe, tank, and equipment applications
 - b) For pipe applications, fabricated to shape from continuous bun stock per ASTM C450 and ASTM C585
 - c) Does not use CFC or HCFC blowing agents in the manufacturing process
 - d) Surface Burning Characteristics, maximum: 25/450 flame spread/smoke developed, ASTM E84
 - e) Thermal Conductivity (k-factor) maximum: 0.19 BTU-in/hr-ft²·°F (0.027 W/m·°C) at 75°F (24°C) mean temperature after 180 days of aging, ASTM C518
 - f) Density, minimum: 2.5 lb/ft³ (40.0 kg/m³), ASTM D1622
 - g) Service Temperature, maximum: 300°F (149°C)
 - h) Water Absorption, maximum: <0.7% by volume after 24-hour immersion, ASTM C272
 - i) Water Vapor Permeability, maximum: 3.0 perm-in., ASTM E96

4.1.1.2

- A. Manufacturer: Johns Manville
- B. Product: Trymer® 3000 PIR, compliant with ASTM C591, Grade 2, Type III
- C. Material Physical Properties:
 - a) Rigid, closed-cell, preformed polyisocyanurate insulation for pipe, tank, and equipment applications
 - b) For pipe applications, fabricated to shape from continuous bun stock per ASTM C450 and ASTM C585
 - c) Does not use CFC or HCFC blowing agents in the manufacturing process
 - d) Surface Burning Characteristics, maximum: 25/450 flame spread/smoke developed, ASTM E84
 - e) Thermal conductivity (k-factor) maximum: 0.19 BTU-in/hr-ft²·°F (0.027 W/m·°C) at 75°F (24°C) mean temperature after 180 days of aging, ASTM C518
 - f) Density, minimum: 3.0 lb/ft³ (48.0 kg/m³), ASTM D1622
 - g) Service Temperature, maximum: 300°F (149°C)
 - h) Water Absorption, maximum: <0.7% by volume, ASTM C272
 - i) Water Vapor Permeability, maximum: 3.0 perm-in., ASTM E96

4.1.2 Vapor Retarder

4.1.2.1

- A. Manufacturer: Transcendia
- B. Distributor: Johns Manville
- C. Product: Saranex® 560CX Vapor Retarder, compliant with ASTM C1136, Type VIII

D. Material Physical Properties:

- a) Film or tape – polyvinylidene chloride (PVDC)
- b) Surface Burning Characteristics, maximum: 25/50 flame spread/smoke developed, ASTM E84
- c) Thickness: 6 mil, avg., ASTM D374
- d) Permeance: 0.01 perms, ASTM E96
- e) Service Temperature, maximum: 250°F (121°C)
- f) If using a triple-layer of PIR, use a double-layer vapor retarder design. Apply the secondary vapor retarder between the outermost foam insulation layer and the next inner layer of foam insulation. Apply a primary vapor retarder to the outermost foam insulation layer. Refer to [Section 5.1](#) and [Section 5.3](#) for details.
- g) In a double-layer vapor retarder system the primary layer and the secondary layer may be a specified combination of butyl, Mylar-Aluminum-Mylar (MAM) or Polyester-Aluminum-Polyester (PAP) type vapor retarder. For example, the primary layer is butyl and the secondary layer is MAM.
- h) For laminated membrane type vapor retarders and vapor retarder mastics, consult the manufacturer's literature and installation guidelines before application of metal jacketing.
- i) Vapor retarder may be factory or field applied to the outer surface of pipe insulation.

4.1.3 Metal Jacketing and Banding

4.1.3.1

- A. Manufacturer: Johns Manville
- B. Product: Aluminum Metal Jacketing, compliant with ASTM C1729
- C. Material Physical Properties:
 - a) Jacketing alloy on pipe and equipment compliant with ASTM B209
 - b) Surface Burning Characteristics (plain mill with Polyfilm Moisture Barrier (PFMB)): 0/5 flame spread/smoke developed, ASTM E84
 - c) Thickness per NPS: Refer to Table 3 of ASTM C1729 for pipe sizes and gauges.
 - d) Aluminum jacketing for all fittings, tees, elbows, valves, caps, etc. should be pressed sectional, or field-fabricated to snugly fit around insulation and have a PFMB heat laminated to the interior of the jacketing or elbow.
 - e) The use of aluminum jacketing with a pigmented paint coating on the exterior will provide a higher emittance and reduce the insulation thickness required.
 - f) Aluminum protective jacketing should not be considered a vapor retarder. Refer to [Section 4.1.2](#) for vapor retarder recommendations.

4.1.3.2

- A. Manufacturer: Johns Manville
- B. Product: Stainless Steel Jacketing, compliant with ASTM C1767
- C. Material Physical Properties:
 - a) Jacketing alloy on pipe and equipment compliant with ASTM A240

- b) Surface Burning Characteristics, maximum: 25/50 flame spread/smoke developed, ASTM E84
- c) Thickness per NPS: Refer to Table 2 of ASTM C1767 for pipe sizes and gauges.
- d) Stainless jacketing for all fittings, tees, elbows, valves, caps, etc. should be pressed, section, or field-fabricated to fit closely around insulation.
- e) Stainless steel protective jacketing should not be considered a vapor retarder. Refer to [Section 4.2.1](#) for vapor retarder recommendations.

4.1.3.3

- A. Manufacturer: Johns Manville
- B. Product: Stainless Steel Strapping/Banding
- C. Material Physical Properties:
 - a) Banding compliant with ASTM A240
 - b) Thickness: 0.015 in (0.38 mm) and 0.020 in (0.5 mm)
 - c) Width: ½ in (12.7 mm) and ¾ in (19.1 mm)
 - d) Use where corrosion resistance is needed
 - e) For 16" OD and above, ¾" wide banding shall be used

4.1.3.4

- A. Manufacturer: Johns Manville
- B. Product: Aluminum Strapping/Banding
- C. Material Physical Properties:
 - a) Banding compliant with ASTM B209
 - b) Thickness: 0.020 in (0.5 mm)
 - c) Width: ½ in (12.7 mm) and ¾ in (19.1 mm)
 - d) Use where corrosion resistance is not needed

4.2 Adhesives, Joint Sealers, and Mastics

- 4.2.1 Adhesives, joint sealers, and mastics can be used in contact with Trymer insulation. Fabrication and attachment adhesives should be 100% solids, reactive cure adhesive for use when Trymer insulation is being bonded to impermeable surfaces, such as pipes, tanks, and equipment, or between sections or layers of Trymer and/or other low permeability materials. The adhesive should have a service temperature range from -275°F to 200°F (-171°C to 93°C) and be suitable for the temperature range expected at the bond line. Consult manufacturer for product recommendation and application details or approved alternatives. The service temperature listed below in Table 1 is the temperature at the coated surface, not the operating temperature of the system.

Table 1: Adhesive Recommendations

Adhesives	Service Temperature
Foster® 81-33 Fire Resistive Adhesive (solvent-based)	-75°F to 300°F (-59°C to 149°C)
Foster® 81-84NH Urethane Adhesive Sealant (two component Urethane)	-260°F to 200°F with PIR (-162°C to 93°C)
Foster® 82-77 Cryogenic Adhesive (three component Epoxy)	-320°F to 250°F (-195°C to 121°C)

- 4.2.2 Where mastic/fab/mastic is used as the vapor retarder on pipes, fittings, tanks, and equipment, a high performance, low permeance (< 0.02 perms), flexible, water resistant, vapor retarder mastic or coating may be used to complete the vapor retarder on the outer surface of the insulation. Consult coating and mastic manufacturer for recommended equivalent products.

Table 2: Mastic and Membrane Recommendations

Mastics and Membrane	Service Temperature
Foster® 60-38/39 Monolar II Mastic (solvent-based)	-40°F to 250°F (-40°C to 121°C)
Foster® 60-90/91 Monolar Mastic (solvent-based)	-50°F to 250°F (-46°C to 121°C)
Foster® 60-95/96 Monolar Coating (solvent-based)	-50°F to 250°F (-46°C to 121°C)
Foster® Butylar™ NXT Vapor Barrier Jacketing Butyl Rubber Based Adhesive with PAP Facing	-40°F to 284°F (-40°C to 140°C)

- 4.2.3 Apply a vapor retarder type joint sealer on insulation longitudinal joints and butt joints to prevent moisture and moisture vapor infiltration. For a multi-layer system, seal joints on outermost layers. Joints on inner most layer should be left un-sealed.
- 4.2.4 Apply vapor stop sealant at insulation terminations and where specified at flanges, valves, pipe supports, and other critical areas to prevent moisture migration within the insulation system. Apply vapor stop sealant with mesh reinforcement. Vapor stop sealant should have a service temperature range from -320°F to 250°F (-195°C to 121°C) and maximum permeance of 0.02 perms by ASTM E96, Method E. Consult manufacturer for product recommendations and application details. The service temperature listed below in Table 3 is the temperature at the coated surface, not the operating temperature of the system. The materials listed below are suggestions and equivalent products may be used.

Table 3: Joint Sealant & Vapor Stop Sealant

Joint Sealants & Vapor Stop Sealant:	Service Temperature
Foster® 95-50 Flextra® Sealant (solvent-based)	-261°F to 200°F with PIR (-163°C to 93°C)
Foster® 95-55 Insulation Joint Sealant (solvent-based)	-261°F to 200°F with PIR (-163°C to 93°C)
Foster® 90-61 Cryolar™ 1K Vapor Stop Sealant (solvent-based)	-320°F to 250°F (-195°C to 121°C)
Foster® 90-66 Cryogenic Vapor Stop Sealant (solvent-based)	-320°F to 180°F (-195°C to 82°C) (up to 250°F (121°C) intermittent)

- 4.2.5 Solvent-based, water-based or hot melt adhesives may be used to attach the Saranex Film or other type of specified vapor retarder to the outer surface of the Trymer insulation.

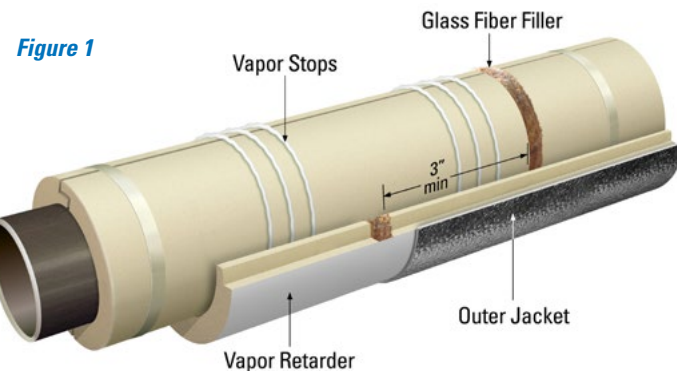
Refer to the specified vapor retarder installation guidelines. Consult adhesive manufacturer's literature for instructions on handling adhesives, including required operating temperatures. Potential adhesives for use in this application include:

- a) Childers® CP-124 adhesive (solvent-based)
- b) Foster® 81-15 adhesive (solvent-based)
- c) Foster® 85-45 adhesive (aerosol)
- d) Foster® 85-60 adhesive (water-based)
- e) Foster® 83-13HM (hot melt)

4.2.6 Flashing sealants should be vapor retarder type, moisture and water-resistant, non-hardening and flexible, and used to seal around protrusions and insulation terminations and to seal jacketing slip joints. Service temperatures range from -40°F to 250°F (-40°C to 121°C). Typical jacketing sealants are Childers® Chil-Byl® CP-76 and Foster Elastolar® 95-44 from H.B. Fuller Construction Products Inc. Equivalent products may be used.

4.3 Contraction/Expansion Joints

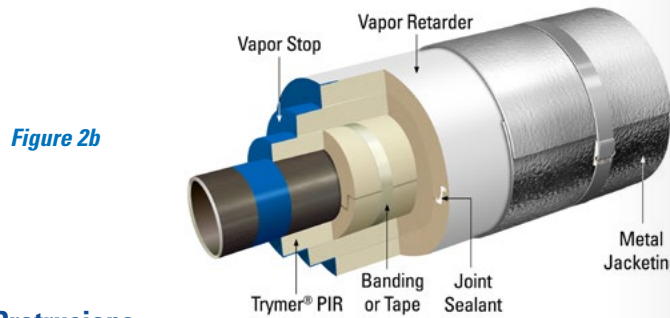
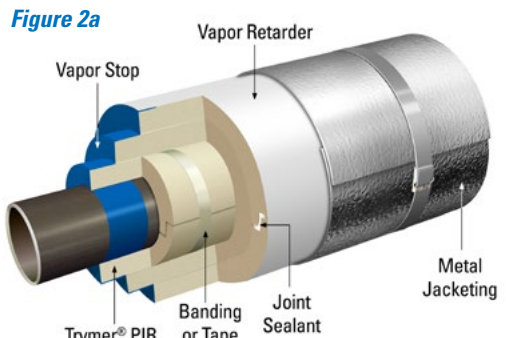
- 4.3.1 Determine the location of contraction/expansion joints by considering the expected pipe movements, changes in direction, and supports that will minimize the natural movement of the pipe (also known as a fixed point). Change in direction includes the bottom elbow and the top elbow of a vertical run. Use contraction/expansion joints when the distance between fixed points or change in direction or a combination is about 21 ft (6.5 m) for vertical or horizontal runs.
- 4.3.2 For vertical runs with less than 21 ft (6.5 m) between supports, install contraction/expansion joints above the bottom elbow, below the top elbow, and on either side of other supports.
- 4.3.3 Install contraction/expansion joints in all singer layers, and the outer layers of a multi-layer, insulation systems.
- 4.3.4 Contraction/expansion joints should have a minimum offset of 3 in (75 mm) between layers and a maximum width of 1 in (25 mm) after compression.
- 4.3.5 Fill contraction/expansion joints with a resilient, mineral fiber, low-density unfaced fiberglass, or equivalent. The filler insulation should have its fibers oriented parallel to the direction of the pipe. The thickness of the contraction/expansion joint filler should be twice the final width of the contraction/expansion joint. When installed it should be compressed to about half of its starting thickness to fill the width of the joint entirely. Refer to Figure 1 (below).



- 4.3.6 Apply vapor seals on the PIR insulation on both sides of the expansion joint. The vapor seal, as part of the contraction joint, should be flexible butyl rubber. Do not allow sealant beads to cure prior to installation of outer layer of insulation.
- 4.3.7 Consult with the appropriate engineer/designer to determine the proper spacing and filler material for the contraction/expansion joints for each system.

4.4 Vapor Stops

- 4.4.1 Install vapor stops on all protrusions penetrating the insulation, vapor retarder(s), and jacketing. Some example areas are flanges, flanged valves, pipe supports, relief valves, flow valves, structural support brackets, vents, insulation terminations and instrument connections.
- 4.4.2 Mastic should be selected based on the service temperature of the system. See Section 4.2.2.
- 4.4.3 The vapor stop extends cross-sectionally through the insulation.
- 4.4.4 Before the outer most vapor retarder membrane and mastic, apply 1.5 in to 2.0 in (38 mm to 51 mm) of a reinforced vapor stop coating and extend the vapor stop 3 in (75 mm) on the outer surface of the Trymer PIR insulation and 3 in (75 mm) onto the underlying pipe surface, either under the insulation or away from the insulation. Tie the vapor stop into both the primary and secondary vapor retarders. Refer to Figure 2a and 2b (below). The project engineer or specifier will determine which installation method is used.
- 4.4.5 Ensure the vapor stop sealant is fully dry before covering with adjacent insulation, vapor retarder, or jacketing.



4.5 Protrusions

- 4.5.1 Insulate protrusions, excluding nozzles, that require insulation with a thickness equal to the insulation thickness of the pipe insulation or a minimum of 1.5 in (38 mm), whichever is greater. The protrusion should be insulated for a distance equal to four times the pipe insulation thickness measured at the pipe or equipment surface.

SECTION 5 – APPLICATION

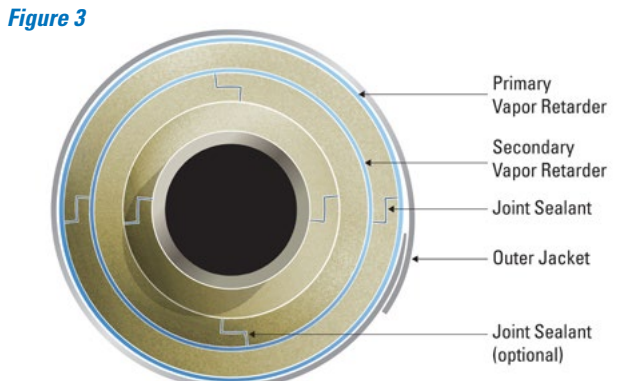
5.1 Piping General

- 5.1.1 If the stainless steel pipe or equipment being insulated will spend a significant amount of time between the temperatures of 140°F and 250°F (60°C and 121°C), it is recommended to apply a corrosion-inhibiting coating to the metal surface. Refer to Section 7 for coating recommendations.
- 5.1.2 All piping operating at LNG temperatures, requiring more than 5 in (127 mm) of insulation, should be applied in three layers. All piping requiring less than 5 in (127 mm) of insulation should be applied in two layers. At 5 in thickness, PIR insulation can be installed in either two or three layers. Refer to Table 4.

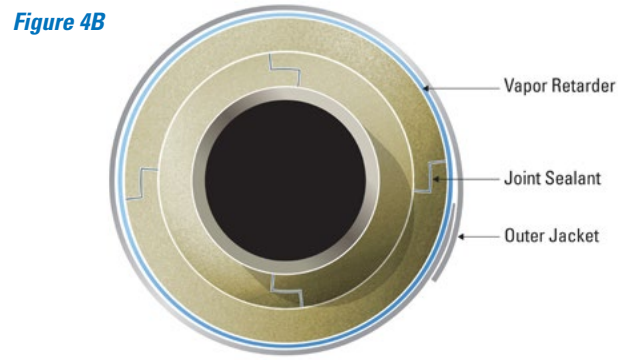
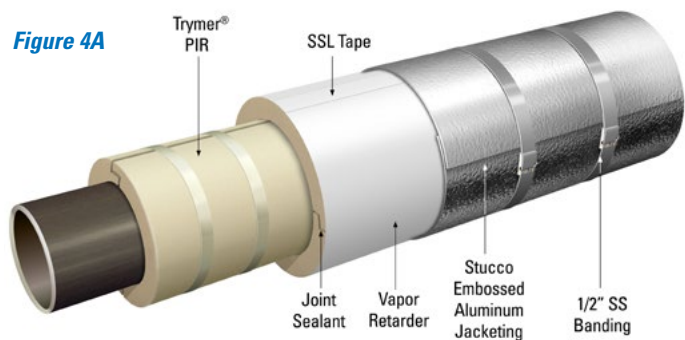
Table 4: Insulation Thickness Details

Total Thickness in	Total Thickness mm	Inner layer in	Inner layer mm	Middle layer in	Middle layer mm	Outer layer in	Outer layer mm
2	51	1	25.5	-	-	1	25.5
2.5	63.5	1	25.5	-	-	1.5	38
3	76	1.5	38	-	-	1.5	38
3.5	89	1.5	38	-	-	2	51
4	101.5	2	51	-	-	2	51
4.5	114	2	51	-	-	2.5	63.5
5	127	2.5	63.5	-	-	2.5	63.5
5 (alt)	127	1.5	38	1.5	38	2	51
5.5	140	1.5	38	2	51	2	51
6	152.5	2	51	2	51	2	51
6.5	165	2	51	2	51	2.5	63.5
7	178	2	51	2.5	63.5	2.5	63.5
7.5	190.5	2.5	63.5	2.5	63.5	2.5	63.5
8	203	2.5	63.5	2.5	63.5	3	76
8.5	216	2.5	63.5	3	76	3	76
9	229	3	76	3	76	3	76
9.5	241.5	3	76	3	76	3.5	89
10	254	3	76	3.5	89	3.5	89
10.5	267	3.5	89	3.5	89	3.5	89
11	280	3.5	89	3.5	89	4	101.5

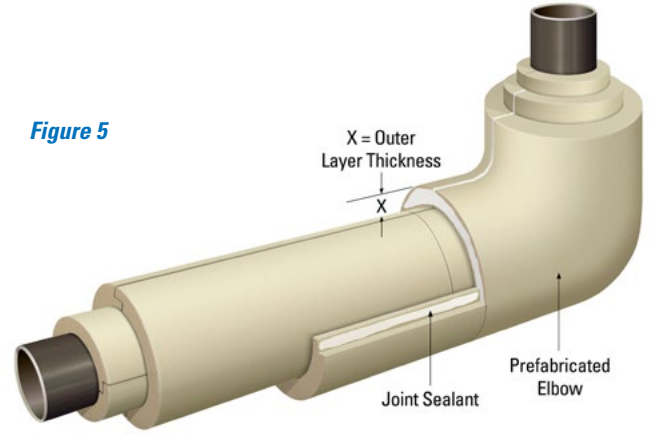
- 5.1.3 For triple-layer systems, install the longitudinal joints of the inner, middle, and outer layers 90° to each other, with the inner layer joints in the 3 and 9 o'clock positions, the middle layer joints in the 12 and 6 o'clock positions, and the outer layer joints in the 3 and 9 o'clock positions. Stagger all circumferential joints of inner, middle and outer layers by minimum 6 in (152 mm). Refer to Figure 3 (below).



- 5.1.4 In double-layer systems, 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. Stagger all circumferential joints of inner and outer layers by minimum 6 in (152 mm). Refer to Figure 4A and Figure 4B (below).



- 5.1.5 At the discretion of the specifier, the insulation should be fabricated with flat, shiplap, or tongue and groove longitudinal joints and flat or shiplap butt joints.
- 5.1.6 Install prefabricated insulation fittings on elbows, tees, and valves. Insulation fittings should be the same thickness as the thickness of the adjacent pipe insulation and, at the discretion of the specifier, should be fabricated with flat, shiplap, or tongue and groove longitudinal joints. Refer to Figure 5 (below).

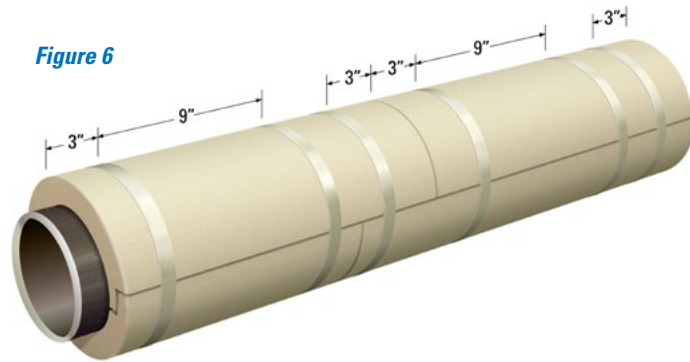


- 5.1.7 In a triple-layer insulation system, the innermost layer should not be installed with sealants. The middle layer may have sealants (optional) while the outer most layer must have sealants. In triple-layer systems, the inner, middle, and outer

layers should remain independent of each other to allow movement between the layers. Refer to Figure 1.

- 5.1.8 In double-layer insulation systems, the inner layer should not be installed with sealants. In double-layer systems, the inner and outer layer should remain independent of each other to allow movement between the layers. Refer to Figure 4A.
- 5.1.9 Install 3/4 in (19.1 mm) wide fiber-reinforced tape to secure insulation and secondary vapor retarder. The tape should be installed with a 50% circumferential overlap. Apply tape per Figure 6 (below).

Figure 6



- 5.1.10 Secure insulation with fiber-reinforced tape on both inner and outer layers of a multi-layered system. Segmental pipe insulation should be secure with 3/4 in (19 mm) stainless steel bands.
- 5.1.11 All external surfaces of installed PIR insulation on piping and equipment shall be protected with a vapor retarder. On piping and equipment operating below -70°F (-57°C) temperature, a secondary vapor retarder shall be installed on a next layer in (adjacent to) the outermost layer in a multi-layer insulation system.
- 5.1.12 Secondary Vapor Retarder
 - 5.1.12.1 On a triple-layer insulation system, a secondary vapor retarder shall be installed on the middle layer. The secondary vapor retarder shall consist of PAP or mylar film.
 - 5.1.12.2 Secure film with a 3/4 in (19 mm) wide glass fiber-reinforced tape. The vapor retarder film shall have a minimum 3 in (76 mm) overlap sealed with a joint sealing foil-faced butyl or foil/polyester laminate adhesive tape.
 - 5.1.12.3 Adequately seal all joints and terminations with no holidays, fish mouths, tears, or punctures.
- 5.1.13 Primary Vapor Retarder
 - 5.1.13.1 The primary vapor retarder shall consist of either membrane or reinforced mastic or combination thereof.
 - 5.1.13.2 The butyl rubber membrane can be installed on straight runs of piping instead of the usual vapor barrier mastic/fabric system. Install the membrane with a minimum of 3 in (76 mm) overlap. Orient the overlap orientation to shed rainwater.
 - 5.1.13.3 Adequately seal all joints and terminations with no wrinkles, fish mouths, tears, or punctures.
 - 5.1.13.4 Use fabric-reinforced mastic over compound curve surfaces such as equipment heads, elbows, valves, flanges, and fittings. A minimum of two coats of mastic with reinforced fabric shall be applied per mastic

manufacturer's recommendation. Mastic/fab/mastic shall be smooth without wrinkles, tears, holidays, or punctures. Mastic vapor retarder shall overlap membrane vapor retarder and vapor stops to provide continuous seal.

- 5.1.14 Install contraction/expansion joints as described in Section 4.3 (illustrated in Figure 1) or equivalent alternate design as approved by owner engineer. The design engineer must specify the spacing of contraction/expansion joints separately for each system.
- 5.1.15 All insulation should be tightly butted and free of voids and gaps at all joints. Neatly align all fasteners and bands and ensure overall work is of high-quality appearance and workmanship.
- 5.1.16 Install vapor stops on either side of insulated valves. Valve stations left exposed, or other fittings, elbows, tees, insulation terminations, etc. where the chance of moisture infiltration is high, also require vapor stops. Install per the details in Figure 7 and Figure 8 (below) or an equivalent alternate design.
- 5.1.17 Foamed-in place polyurethane option (shown in Figure 7 and Figure 8) should be used only when the pipe and fittings are wrapped with foil or plastic to allow maintenance access. Otherwise foamed-in place polyurethane cannot be removed without damaging insulation and vapor stop.

Figure 7

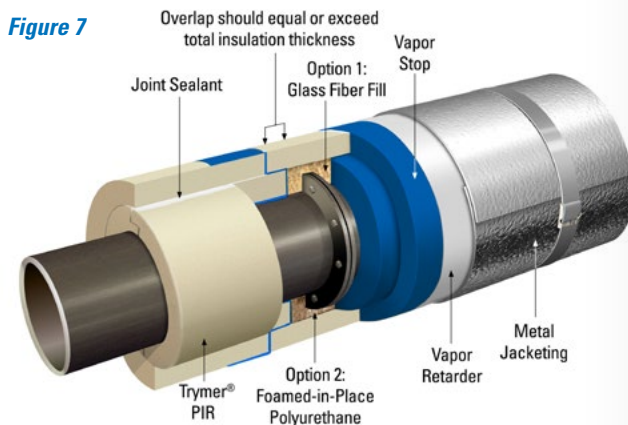
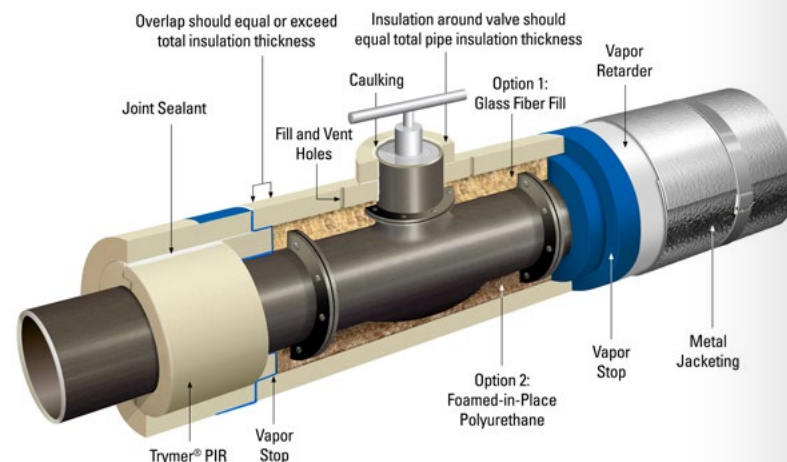


Figure 8



- 5.1.18 Wrap elbows and fittings with tape, membrane or cover with a vapor retarder mastic type product. If using a tape, wrap in a spiral configuration. If using a mastic type vapor retarder at the fittings and elbows, form the mastic so that fitting covers can be applied true and tight. Vapor retarders must be continuous.
- 5.1.19 On factory-applied films, seal the lap joint with Self-Sealing Lap (SSL) tape. To ensure good adhesion between the tape and the vapor retarder, areas of the vapor retarder surface where SSL tape will be adhered should be cleaned and free of dust, grease, oil, etc. before applying the SSL. For other types of factory-applied vapor retarders, consult the manufacturer's recommendations on installation.
- 5.1.20 Before installing the jacketing on a portion of the piping, ensure the vapor retarder system on that portion is complete and continuous.

5.2 Outdoor Piping

- 5.2.1 This section covers outdoor areas including, but not limited to, process areas, rooftops and rooftop equipment.
- 5.2.2 To prevent color change and potential moisture accumulation, the Trymer PIR should be covered immediately after installation by an appropriate vapor retarder.
- 5.2.3 Cover the specified vapor retarder with a jacketing material within two weeks of installation to eliminate long-term exposure to UV light.
- 5.2.4 Refer to Section 4.1.3 for material specifications on metal jacketing for outdoor use.
- 5.2.5 Overlap outdoor jacketing a minimum of 2 in (51 mm) at circumferential and longitudinal joints. If specifier/designer calls for sealing the metal jacketing joints, use a suitable metal flashing sealant applied inside the joint prior to closing and banding of the joint (rather than applying the sealant on the exterior lip of the joint). On horizontal straight pipe, the longitudinal joint shall be located at the 3 to 4 o'clock or 8 to 9 o'clock position and the joint opening shall point downward or away from prevailing winds to naturally shed water.
- 5.2.6 Neatly secure straight sections of jacketing with bands and seals with a maximum spacing of 12 in (305 mm) on center. Secure end joints with bands and seals centered directly over joint. Do not use screws, staples, or other fasteners that can penetrate a vapor retarder.
- 5.2.7 In areas where screws or rivets are needed to secure the metal jacketing (examples being equipment heads and protrusions, such as valves, nozzles and T's), install a sacrificial layer of elastomeric foam over the primary vapor retarder to prevent punctures resulting in damage to the vapor retarder or underlying Trymer PIR insulation. (See Figure 9.)
- 5.2.8 Where the insulation ends, the termination end must be sealed with a vapor retarder mastic (vapor stop), then covered with a metal cap made of the same material as the pipe jacketing and sealed with caulk. Refer to Figure 10 (above right).

Figure 9

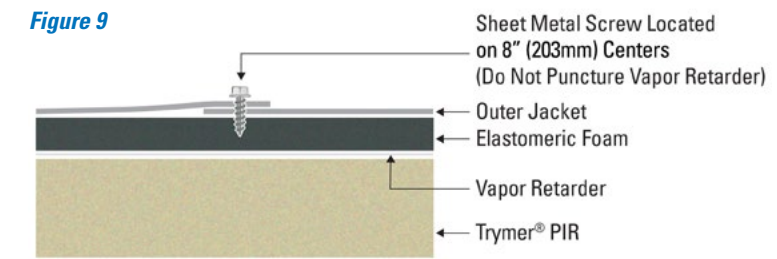
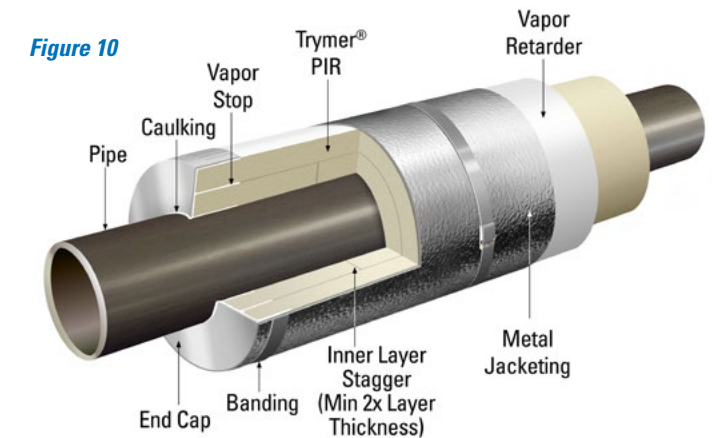


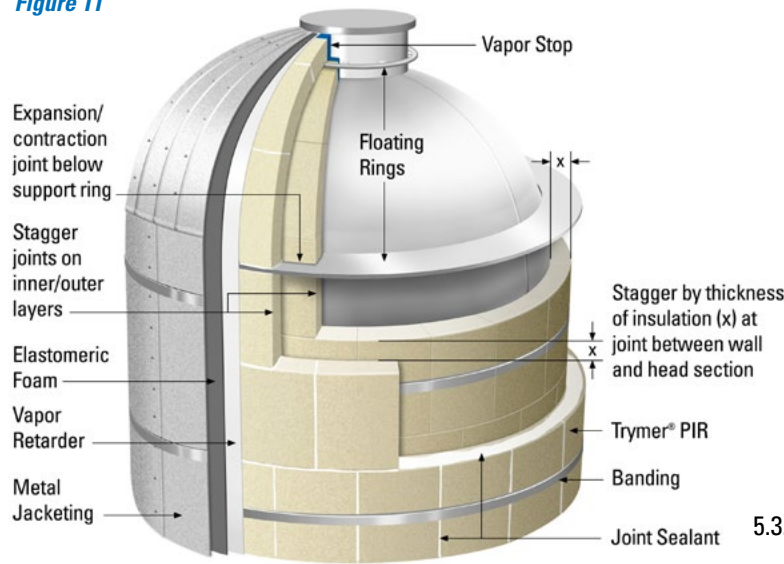
Figure 10



5.3 Tank, Vessel and Equipment Insulation

- 5.3.1 All insulation materials should be the same for vessels, equipment, tanks, and associated piping.
- 5.3.2 Tank and vessel-head insulation should be double-contoured curved segments cut to fit in a single piece or segments per ASTM C450. Cut segments to eliminate voids at the head section. Additionally, head segments should be cut into as few pieces as possible to eliminate through-joints once installed.
- 5.3.3 Fabricate curved segments for shell to fit the contour of the surface in equal-sized pieces to cover the vessel with a minimum number of through-joints. Apply the curved segment so that its length is parallel to the greatest length of surface area to be insulated. Ensure all successive end joints are staggered. Select appropriately sized segments applied to curved surfaces to eliminate gaps between surfaces and segments. Apply curved segment insulation in multiple-layer construction when required to meet specified insulation thickness. In multi-layer applications, stagger the horizontal and vertical joints of the inner and outer layers of curved segments. Refer to Figure 11. The minimum stagger should equal the thickness of the inner insulation layer. All joints shall be tightly butted and without voids or gaps. Apply joint sealer between uninsulated protrusions of the equipment wall and insulation.
- 5.3.4 Vertical vessels greater than 4 ft (1.2 m) in diameter require an insulation support ring welded or bolted around the bottom tangent line or on vessel skirt of the vessel to prevent the shell insulation from sliding down. Additional support rings might be needed and should be spaced at a maximum of 12 ft 1 in (3.7 m) intervals to allow for contraction joint space. Support rings may be either welded or bolted to vessel shell to support intermediate segments of insulation. Welded support ring(s) should be installed by a vessel fabricator.

Figure 11



- 5.3.5 In multi-layer systems, seal all longitudinal and butt joints in the outer layers with joint sealant.
- 5.3.6 In multi-layer applications, stagger the horizontal and vertical joints of the inner and outer layer curved segments. Refer to Figure 11 (above).
- 5.3.7 Secure each insulation layer with stainless steel bands on 12 in (305 mm) centers. For vertical equipment, provide contraction joints below each insulation support ring. For horizontal equipment, install contraction joints midway between saddles and on 30 ft (9.1 m) centers thereafter. Pack the contraction joint space with mineral fiber type insulation as detailed in Section 4.3.
- 5.3.8 Insulate legs and appendages attached directly to the shell out from the vessel head or wall with four times the insulation thickness and seal the insulation termination with a vapor stop.
- 5.3.9 Secondary Vapor Retarder
 - 5.3.9.1 On equipment operating below -70°F (-57°C) temperature, a secondary vapor retarder shall be installed on a second layer from outermost layer in a multi-layer insulation system. The secondary vapor retarder shall consist of PAP or mylar film secured with a ½ in (12.7 mm) wide glass fiber reinforced tape. The vapor retarder film shall have a minimum 3 in (76 mm) overlap sealed with a joint sealing foil-faced butyl or foil/polyester laminate adhesive tape.
 - 5.3.9.2 All joints and terminations shall be adequately sealed with no holidays, fish mouths, tears, or punctures.
- 5.3.10 Primary Vapor Retarder
 - 5.3.10.1 Apply the primary vapor retarder film (membrane) or reinforced mastic to all external surfaces of piping and equipment insulation.
 - 5.3.10.2 The primary vapor retarder should be a self-sealing butyl rubber sheet membrane that has factory-applied butyl compound bonded to mylar or PAP foil. The butyl rubber membrane can be installed on straight sections

of vessel walls and equipment instead of the usual vapor barrier mastic/fabric system. Install the membrane with a minimum of 3 in (75 mm) overlap. Orient the overlap such that it sheds rainwater. Adequately seal all joints and terminations with no wrinkles, fish-mouths, tears, or punctures.

5.3.10.2.1 As an alternative to self-sealing butyl rubber sheet membrane, Saranex® 560 CX Vapor Retarder Film can be used on equipment. Tightly wrap the vessel or equipment insulation circumferentially with Saranex® CX Film. Overlap the seams by a minimum of 2 in (51 mm). Seal the overlapped seams with Saranex® CX Tape. On vertical vessels, position the overlaps to naturally shed rainwater.

5.3.10.3 Use fabric-reinforced mastic over compound curve surfaces such as equipment heads and fittings. Apply a minimum of two coats of mastic with reinforced fabric per mastic manufacturer's recommendation. Ensure the mastic/fab/mastic is smooth without wrinkles, holidays, or punctures. Overlap the membrane vapor retarder and vapor stops with the mastic vapor retarder to provide a continuous seal.

5.3.11 Protect the primary vapor retarder with metallic jacketing. Metal jacketing securement should not puncture the vapor retarder. Refer to Figure 11 (above left).

5.3.12 Metallic Jacketing

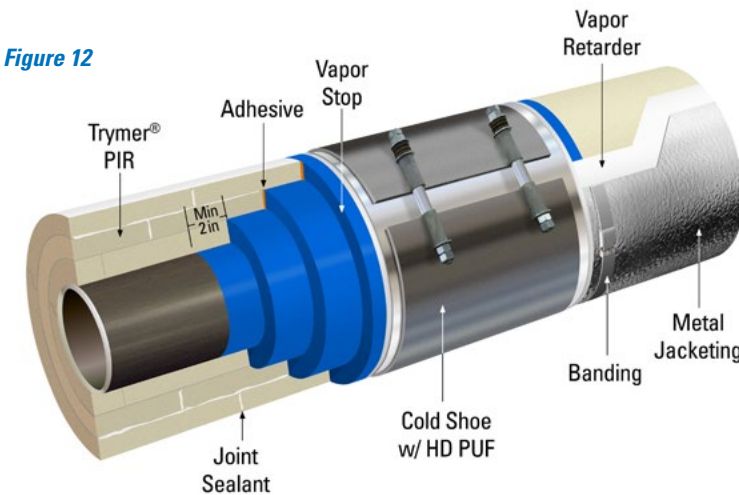
- 5.3.12.1 On outdoor equipment including tanks and vessels, where fire protection is not required, use aluminum jacketing. Use stainless steel jacketing where fire protection is required. Refer to Section 4.1.3 for proper material selection.
- 5.3.12.2 In areas where screws or rivets are needed to secure the metal jacketing, install a sacrificial layer of elastomeric foam over the primary vapor retarder to prevent damage to the vapor retarder or underlying Trymer PIR insulation.

5.4 Cryogenic Pipe Supports

- 5.4.1 Install, seal, and protect cryogenic pipe supports per pipe support manufacturer's instructions.
- 5.4.2 Pipe insulation layering should match the number of layers and thickness of pipe support high density PIR, Polyurethane Foam (PUF) or alternate equivalent.
- 5.4.3 Install the vapor stops on the ends of the insulation of the pipe support. Install remaining pipe installation per Section 5.1.
- 5.4.4 Install a minimum of 12 in (305 mm) long pipe insulation sections against pipe support insulation. Adhere the circumferential joints of pipe insulation to pipe support insulation with adhesive. Seal the longitudinal joints of pipe insulation with joint sealer. Refer to Section 4.2 for adhesives, joint sealants, and mastics.
- 5.4.5 Pipe insulation vapor retarder should overlap pipe support vapor retarder.

- 5.4.6 Install metal jacketing so that it overlaps the pipe support jacketing but clears pipe support cradle. Refer to Figure 12 (below).

Figure 12



5.5 Valves and Flanges

- 5.5.1 Use prefabricated, molded, or routed insulation fittings when commercially available.
- 5.5.2 Fit and assemble insulation for all fittings with tight joints with as few joints as possible. Join prefabricated assemblies with adhesive designed for use in low-temperature applications.
- 5.5.3 When not commercially available, insulation for fittings, valves, and flanges should be shop-routed or fabricated from pipe insulation in conformance with ASTM C450.
- 5.5.4 The termination of piping insulation at each side of the flanged valve or one side of flanged joints should allow sufficient space for bolt removal and incorporate a reinforced vapor stop with stepped layers enclosed within the flange or valve insulation cover.
- 5.5.5 Fill cavities and voids between the insulation and irregular surfaces with mineral fiber insulation. Refer to Figure 7 and Figure 8.

SECTION 6 – INSPECTION

- 6.1 The owner, general contractor, and insulation contractor should perform an inspection during the insulation installation and upon its completion. Inspection of the installation of the insulation system is not the responsibility of Johns Manville. Johns Manville recommends the use of certified insulation inspectors who maintain current certification through a recognized association. Such associations include but are not limited to National Insulation Association (NIA) or Committee Industrial Insulation (CINI).

SECTION 7 – APPENDICES

- 7.1 Appendix A: Corrosion-Resistant Metal Coatings
 - 7.1.1 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 system. The recommendations below represent the general practice in the industry but do not take the place of proper system design and specification by a qualified design engineer familiar with this type of construction. The owner should consult such an engineer and have them work closely with the fabricator, the contractor, and JM to help ensure a properly designed, installed, and long-lasting insulation system free of corrosion.

7.1.2 Specific Recommendations

- 7.1.2.1 Stainless Steel: If operating in a temperature range between 140°F and 300°F (60°C and 149°C) or if in a cycling temperature service where the service temperature is between 140°F and 300°F (60°C and 149°C) for more than 20% of the time, coat all 300 series stainless steel with an epoxy primer at 0.2 in (5 mm) thickness and an epoxy finish coat at 0.2 in (5 mm) thickness. Consult a coating manufacturer for appropriate coating materials and application methods based on the operating temperature range of the equipment.
- 7.1.2.2 Carbon Steel: All carbon steel operating at a service temperature between 32°F and 300°F (0°C and 149°C), or in cycling temperature service where the service temperature is between 32°F and 300°F (0°C and 149°C), for more than 20% of the time should be, at a minimum, primer coated with a suitable corrosion inhibiting gel and according to specification an additional epoxy top coat. Consult a coating manufacturer for appropriate coating materials and application methods for the operating temperature range of the equipment.

FOR CUSTOMER SERVICE AND TECHNICAL INFORMATION

The Trymer LNG Guide is intended for use as a reference and is not a step-by-step procedure. Actual conditions encountered during installation may vary from jobsite to jobsite. By providing this guidance, Johns Manville assumes no responsibility for design, engineering, installation, field workmanship, building code compliance, or job safety. Johns Manville Safety Data Sheets (SDS) are available with specific product safety information. For information on other Johns Manville thermal insulations and systems, call 1-800-866-3234 or visit JM.com.



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