Foamular® XPS Pipe Fabrication Billet Installation Guidelines

This specification is offered as a guide to specifiers and installers and should be employed at the discretion of the user. The ultimate design and installation are the responsibility of the engineer or architect. Read the entire guideline before progressing with any actual installation work.

Part 1.00 – General
1.01 SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to the following commercial piping systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

Low Temperature Thermal Insulation

1. Cold or Chilled Water from 32F (0C) to 60F (15.6C)
2. Refrigeration from -70F (-56.7C) to 31F (-0.6C)

B. This guideline is intended for use with pipe insulation fabricated from Owens Corning Foamular® XPS Pipe Fabrication Billets and shall not be used for the purpose of installing any other insulation.

Note to Specifiers: The above temperature ranges are typical for these systems. However, if contract specifications call for service temperatures outside the above ranges, consult the manufacturer's published data to determine operating temperature limitations of the insulation product or products under consideration.

1.02 REFERENCES

A. Thermal insulation materials and accessories shall meet the property requirements of one or more of the following specifications as applicable to the specific product or end use:

1. American Society for Testing of Materials Specifications:
   a) ASTM B 209, "Aluminum and Aluminum-Alloy Sheet and Plate"
   b) ASTM C 272, "Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions"
   c) ASTM C 450, "Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging"
   d) ASTM C 585, "Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing "
   e) ASTM C 755, "Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation"
   f) ASTM C 1136, "Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation"
   g) ASTM D 1621, "Standard Test Method for Compressive Properties of Rigid Cellular Plastics"
   h) ASTM D 2126, "Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging"
   i) ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Materials"

2. National Commercial & Industrial Insulation Standards – MICA Sixth Edition
   a) PIPING – Section 4.2, Plate No. 1 through 9
   b) VESSELS, TANKS AND EQUIPMENT – Section 4.5, Plates No. 25 through 35
   c) REFRIGERATION AND EXTREME LOW TEMPERATURE INSULATION – Section 5.4, Plate No. 42 through 42
3. Ammonia Refrigeration Piping Handbook – IIAR 2000

1.03 DEFINITIONS

A. The term "rigid cellular plastics" as defined by the above specifications includes extruded polystyrene (XPS).

1.04 SYSTEM PERFORMANCE

A. Foamular® Extruded Polystyrene Pipe Fabrication Billets are intended for use in industrial applications only.

B. Insulation material thickness furnished should meet the design specifications required. Design considerations should include the thermal, condensation control, personnel protection, as well as other factors, needed for the specific application.

C. Fire performance of products fabricated using Foamular® Extruded Polystyrene Pipe Fabrication Billets may vary in the field depending on facings and adhesives used in the fabrication process. Fabricators should be consulted if composite fire performance is required.

1.05 QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder, shall be accompanied by manufacturer's current submittal or data sheets showing compliance with applicable specifications listed in Section 1.02 above.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications,

C. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in chilled water or refrigeration insulation work.

1.05 DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or product identification.

B. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during and after installation. No insulation material will be installed that has become damaged in any way. The contractor shall use all means necessary to protect work and materials installed by other trades.

C. Insulation shall be free of moisture in any form prior to installation.

PART 2.0 – Pipe Insulation

2.01 FABRICATED PIPE INSULATION

A. Pipe insulation shall be fabricated from Foamular® XPS Pipe Fabrication Billets manufactured by Owens Corning by Owens Corning Certified Fabricators. Refer to Owens Corning Foamular® XPS Pipe Fabrication Billet data sheet for specific properties required.

B. Sections
- Fabricated pipe insulation shall be manufactured in accordance with ASTM C 450 and meet ASTM C 585 for sizes required in the particular system. It shall be of a type suitable for installation on piping systems as defined in section 1.01 SCOPE above.

C. Fittings
- Valves, valve stations, flanges, elbows, and tees shall be two pieces and pre-fabricated from Owens Corning Foamular® XPS Pipe Fabrication Billets in accordance with ASTM C 450 and meet ASTM C585 for sizes required in the particular system.

D. Large Fittings
- Large diameter valves and flanges may be oversized enough to assist installation. Cavities created by the oversize will be filled with tightly packed fiberglass blanket insulation or polyurethane spray foam in accordance with the MICA or IIRA manuals (Figure 1, Appendix A)

E. Tank & Vessel
- Tanks and vessel head sections shall be preformed or flat cut to fit in single piece segments per ASTM C 450.

2.03 VAPOR RETARDER

A. Refer to ASTM C 755 for information on selection and specification of vapor retarders and sealing tapes.

B. Specific vapor retarders may be factory or field applied to the fabricated pipe insulation in accordance with manufacturer's instructions.

C. The same applies for tanks, vessels and equipment.

D. The following materials are typical for use in the systems defined in Section 1.01 above. Consult manufacturer's literature for proper selection and instructions on safe handling of materials including required operating temperatures:

Vapor Retarder Jackets

a) Polyguard ZeroPerm™, Polyguard – www.polyguardproducts.com
b) Venture Wrap, Venture Tape – www.venturetape.com

Vapor Retarder Joint Sealer Tape

a) Polyguard ZeroPerm™ A, Polyguard – www.polyguardproducts.com
b) Venture Clad, Venture Tape – www.venturetape.com

Fittings

a) Polyguard ZeroPerm™ Tape, Polyguard – www.polyguardproducts.com

2.04 PROTECTIVE JACKETING

A. Indoor Applications

1. PVC Protective jacketing shall not be considered a vapor retarder.

2. Jacketing material shall be PVC. All jacketing materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the MICA or IIRA manuals.

3. All joints of PVC jacket shall be solvent welded to prevent moisture and moisture vapor infiltration into the insulation system.

4. Mechanical or any other fastener capable of penetrating the underlying vapor retarder shall NOT be used to secure the PVC jacketing.

5. The following materials are typical for use in the systems defined in Section 1.01 above. Consult manufacturer's literature for proper selection and instructions on safe handling of materials including required operating temperatures:

PVC Jacketing

PIC Plastics, www.pic-plastics.com

B. **Outdoor Jacketing**

1. Aluminum protective jacketing shall not be considered a vapor retarder.
2. Jacketing material shall meet ASTM B 209 and be Aluminum. All jacketing materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the MICA or IIRA manuals.
3. Banding for holding jacketing in place shall be ½" wide stainless steel.
4. Mechanical or any other fastener capable of penetrating the underlying vapor retarder shall be used to secure the PVC jacketing.

5. The following materials are typical for use in the systems defined in Section 1.01 above. Consult manufacturer's literature for proper selection and instructions on safe handling of materials including required operating temperatures:

Aluminum Jacketing
RPR Products, Inc, - www.rprhouston.com
Standard Metal Industries - www.standardmi.com

2.05 ADHESIVES, JOINT SEALERS AND MASTICS

DO NOT USE SOLVENT BASED ADHESIVES, JOINT SEALERS AND MASTICS.

A. Review all manufacturers' information to insure compatibility with polystyrene prior to use.

B. The following materials are typical for use in the systems defined in Section 1.01 above. Consult manufacturer's literature for proper selection and instructions on safe handling of materials including required operating temperatures:

Mastic
Vapor Retarder
CHIL-PERM WB CP-35, Childers Products Company – www.fosterproducts.com
Weather Barrier
AK-CRYL CP-9, Childers Products Company – www.fosterproducts.com
VI-CRYL CP-10/11, Childers Products Company – www.fosterproducts.com

Vapor Retarder Joint Sealer
CHIL-JOINT CP-70, Childers Products Company – www.fosterproducts.com
Daxcel 161D, Dacar Industries – www.dacar.com

Facing Adhesive
CP 56, Childers Products Company – www.fosterproducts.com
85-50, Childers Products Company – www.fosterproducts.com
85-60, Childers Products Company – www.fosterproducts.com

PART 3.0 - INSTALLATION

Installation of the insulation system should be in conformance with the current edition of the MICA or IIRA manuals. Certain instructions and illustrations are provided here to assist the specifier.

A. General

1. A pipe coating system may be recommended to minimize the likelihood of pipe corrosion (CUI). Consult with the designer or engineer before beginning installation of the insulation system.
2. All insulation shall be tightly butted and free of gaps and voids at all joints.
3. Pre-fabricated insulation fittings for elbows, tees, and valves, shall be the same thickness at fittings as pipe sections.
4. Each layer of insulation shall be secured to the pipe with 3/4" wide fiber reinforced tape. If factory applied facings are used, fiber reinforced tape in not required on the outer layer. (Figure 4, Appendix A)
5. Vapor barrier performance is extremely important; the vapor retarder shall be continuous.
6. 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. (Figure 2, Appendix A)
7. Before outer jacketing can be installed on a portion of the piping, the vapor retarder system on that portion shall be complete.
8. All tape, fasteners, and bands shall be neatly aligned and installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in ammonia refrigeration insulation work.
9. Contraction/expansion joints shall be installed per the MICA or IIRA Manual or approved alternate design. The appropriate designer or engineer must specify the spacing of contraction/expansion joints for each system. (Figure 9 & 14, Appendix A)
10. Allow mastics to dry before installing PVC or Metal Jacketing.
11. Seal around protrusions, such as valve stems with a full bead of silicone sealant.
12. XPS Insulation shall be protected from prolonged exposure to UV light and weather after installation.

B. Outdoor General

1. Outdoor jacketing shall overlap a minimum of 2” at both butt and longitudinal joints.
2. Outdoor jacketing shall be positioned with the overlap facing downward at either the 3’oclock or 9’oclock position.
3. Bands shall be on a maximum 9” on center spacing.
4. End joints shall be secured with bands and seals directly over the joint.
5. Outdoor sections of jacketing and banding shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in chilled water or refrigeration insulation work.

C. Single Layer Systems (Systems with insulation thickness 2-1/2" and less)

Note: In addition to the specifications outlined in the General section above, the following specification shall be followed for single layer systems.

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. Orient longitudinal joints between half sections in the 3 and 9 o'clock position on the pipe. (Figure 10, Appendix A)
2. Seal all joints full depth with joint sealant and spread to uniform thickness so that joints appear tight and uniform. (Figure 3, Appendix A)
3. Install an 18" length half round pipe section on bottom of all pipe hanger saddles with a full half round pipe section on the top to maintain a staggered joint through the pipe hanger saddle. (Figure 8, Appendix A)
4. Insulation and vapor retarder shall be secured with fiber reinforced tape. Use a ¼ circumferential overlap on 12" centers when installing insulation with factory applied facing.
5. Fiber tape shall be applied to the exterior of the insulation/vapor retarder system.
6. Vapor retarder should be oriented such that the longitudinal lap joint overlaps facing downward at either the 3 or 9 o'clock position. Lap joint shall be sealed using SSL tape as a temporary bond. (Figure 6, Appendix A)
7. On factory applied vapor retarder system, lap joint shall be sealed with SSL tape. (Figure 5, Appendix A)
8. Butt joints shall be covered with vapor retarder tape using the same 3 or 9 o'clock orientation as the longitudinal seam on the vapor barrier.
9. For factory applied facing systems, apply the vapor retarder tape around the butt joint overlap per the manufacturer's installation directions in the appropriate orientation as noted above. (Figure 6, Appendix A)
10. Elbows and fittings shall be wrapped with vapor retarder tape or covered with a mastic type vapor retarder product. Vapor retarder tape shall be wrapped in a spiral configuration. If using mastic type vapor retarder at fittings and elbows, form mastic so that fitting covers can be applied true and tight.
11. Polyurethane foam filled fittings are not acceptable.

D. Double Layer Systems (Systems with insulation thickness of greater than 2-1/2")

Note: In addition to the specifications outlined in the General section above, the following specification shall be followed for double layer systems.

1. Stagger all longitudinal and butt joints between the inner and outer layers. Install the inner and outer layer longitudinal joints perpendicular 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. (Figures 10, Appendix A)
2. Inner layer shall not be installed with sealants. The inner and outer layer shall remain independent of each other so as to allow movement between the layers. (Figure 10, Appendix A)
3. Insulation shall be secured with fiber-reinforced tape on both inner and outer layers except as noted above for factory applied facings.
4. 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. (Figure 11 & 12, Appendix A)
5. Bottom insulation sections in hanger saddles may require higher compressive strength material such as Foamular 400 or 600 Insulation. Consult the designer or engineer for proper load calculations and saddle spacing to determine proper material usage.
6. Saddles shall wrap the insulation in an arc of no less than 120° with the maximum wrap depending upon the load.
7. All fittings shall be cut to full thickness with fabricated shiplap butt ends. The depth of the shiplap shall be cut to the match the thickness of the inner layer. (Figure 13, Appendix A)
8. Insulation and vapor retarder shall be secured with fiber-reinforced tape. Use a ¼ circumferential overlap on 12" centers when installing insulation with factory applied facing.
9. Fiber tape shall be applied to the exterior of the insulation/vapor retarder system.
10. Vapor retarder should be oriented such that the longitudinal lap joint overlaps facing downward at either the 3 or 9 o'clock position. Lap joint shall be sealed using SSL tape or liquid adhesive. (Figure 6, Appendix A)
11. On factory applied vapor retarder system, lap joint shall be sealed with SSL tape. (Figure 5, Appendix A)
12. Butt joints shall be covered with vapor retarder tape using the same 3 or 9 o'clock orientation as the longitudinal seam on the vapor barrier.
13. For factory applied facing systems, apply the vapor retarder tape around the butt joint overlap per the manufacturer's installation directions in the appropriate orientation as noted above. (Figure 6, Appendix A)

14. Elbows and fittings shall be wrapped with vapor retarder tape or covered with a mastic type vapor retarder product. Vapor retarder tape shall be wrapped in a spiral configuration. If using mastic type vapor retarder at fittings and elbows, form mastic so that fitting covers can be applied true and tight.
15. Polyurethane foam filled fittings are not acceptable.

E. Tank & Vessel Equipment Insulation

Note: All insulation and accessory materials shall be the same as those specified on the associated pipe insulation. Follow the same General guidelines for pipe insulation with Tanks & Vessels.

1. Vessel Head
   a) Head segments shall be preformed to fit the contour of the head and eliminate voids.
   b) Flat head sections shall be installed with the same number of layers and thickness as the vessel walls.
   c) The vapor retarder on the head sections shall be continuous and of the same material as the vessel walls of the tank.

2. Vessel Walls
   a) Curved segments shall be fabricated to fit the contour of the surface and in equal width pieces to go around the vessel. (Figure 15, Appendix A)
   b) Every effort should be made to eliminate through joints.
   c) Vertical vessels greater than 4 feet in diameter shall have a insulation support ring welded or bolted around the bottom of the tank to prevent insulation movement.
   d) In double layer systems, stagger both horizontal and vertical joints between the inner and outer layers. (Figure 15, Appendix A)
   e) Where the head meets the side wall in a in a double layer application the inner layer and outer layer shall be offset by a minimum distance equal to the thickness of the insulation.
   f) Secure insulation with minimum ½" steel bands on 12" centers.
   g) On vertical vessels, install vapor retarder and beginning at the bottom of the vessel working upward to create a shingle effect to naturally shed water.
   h) Install vapor retarder with a minimum of 2" overlap at all vertical and horizontal joints.

APPENDIX A

Insulation System – Valve

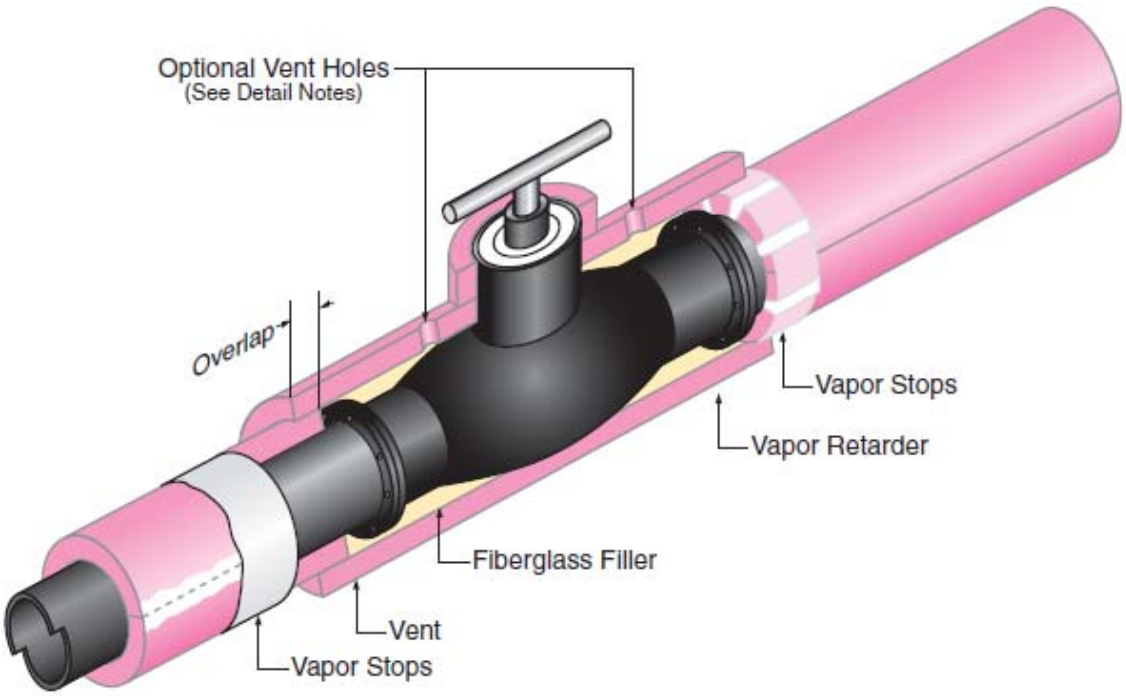


Figure 1

Insulation Details:

- Typical installation should use fiberglass filler in voids as shown.
- Optional installation is to drill vent holes and fill void with foam-in-place polyurethane.
- Overlap section material equal to or greater than the thickness of the insulation.
- Insulation thickness around the valve and packing gland should be equal to the pipe insulation.

Insulation System – Vapor Stop

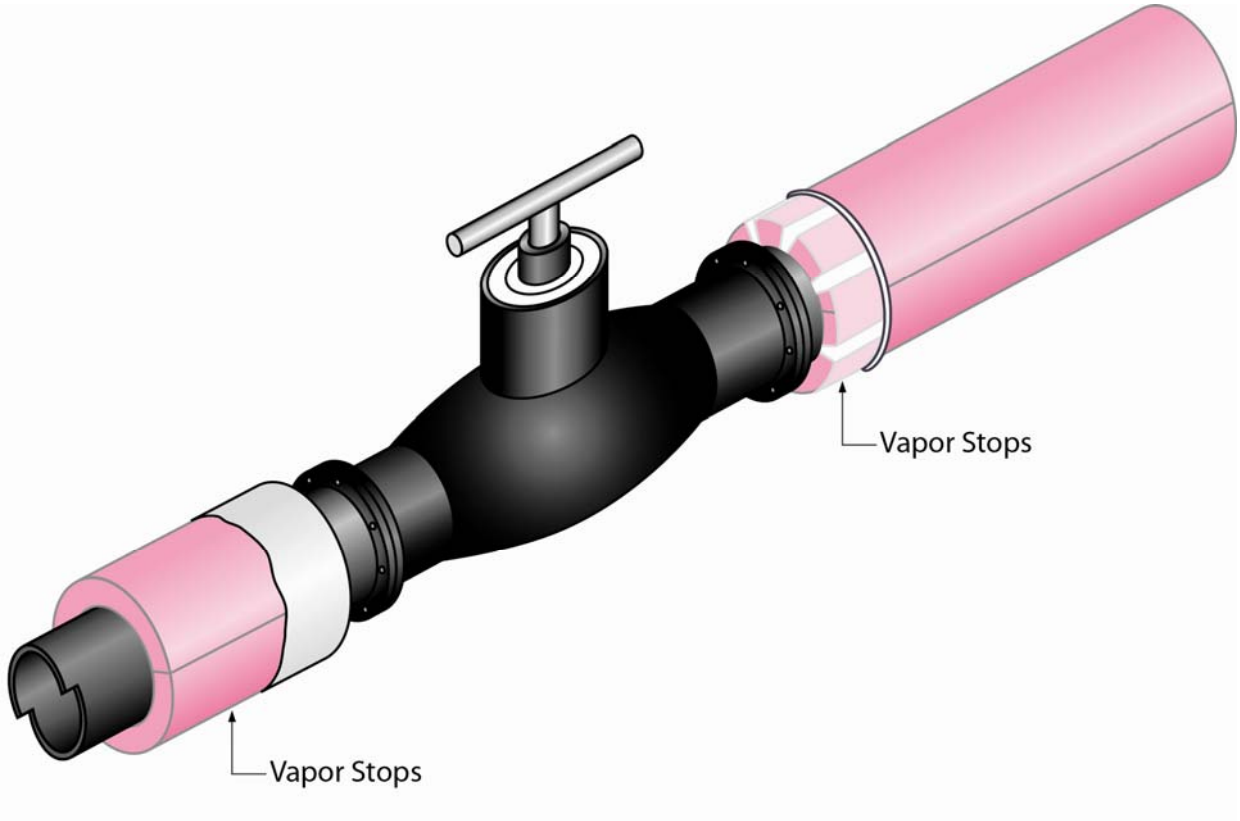


Figure 2

Insulation Details:

- Mastic shall be sealed to the pipe face and lapped back over the top of the vapor retarder is the fitting is left exposed.

Insulation System – Sealant Application

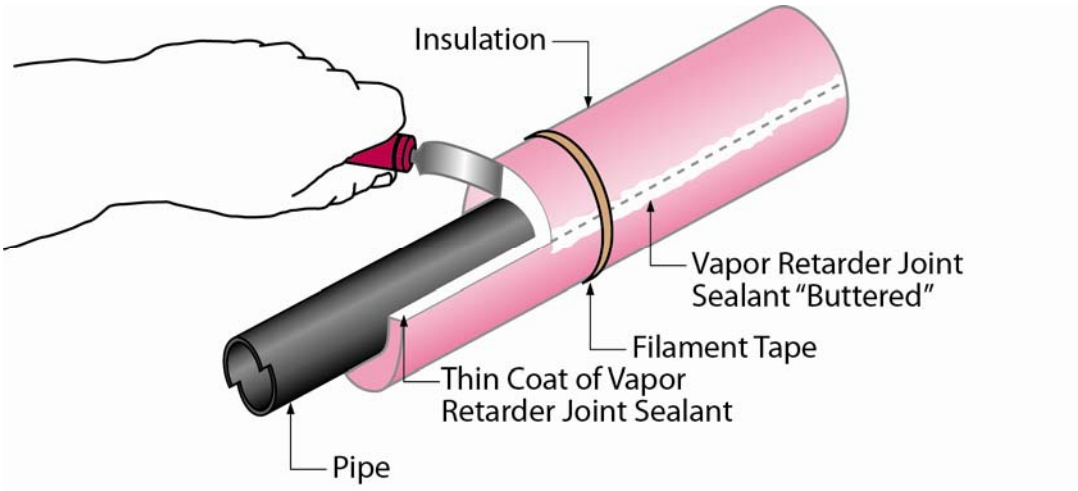


Figure 3

Insulation Details:

- Use a thin coat of sealant over entire joint depth.
  "Butter" excess down the face of the joint as shown.
- On double layer systems use sealant on outer layer only.

Insulation System – Taping Pattern

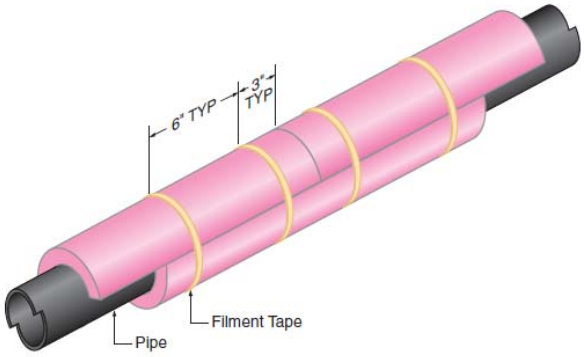


Figure 4

Insulation Details:

- Tape sections every 6 inches. Start 3 inches from end of each section.
- Use two wraps of tape.
- Use ¾" wide nylon or glass filament tape.

Insulation System – Factory Applied Vapor Retarder

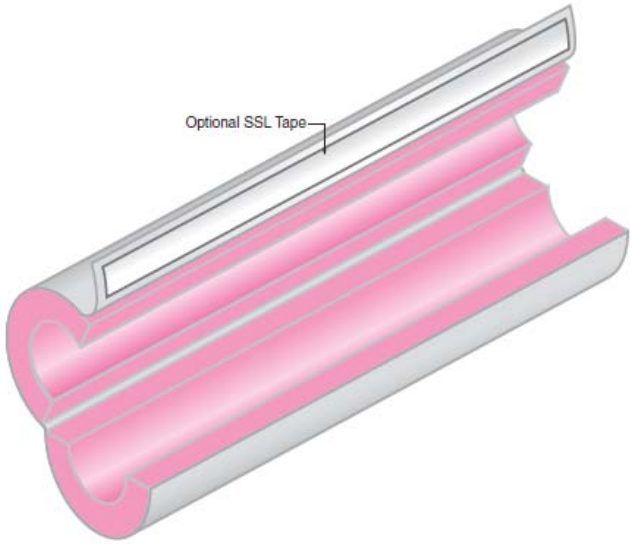


Figure 5

Insulation Details:

- Vapor barrier can be installed using SSL tape as shown. The use of liquid applied adhesives is allowed.

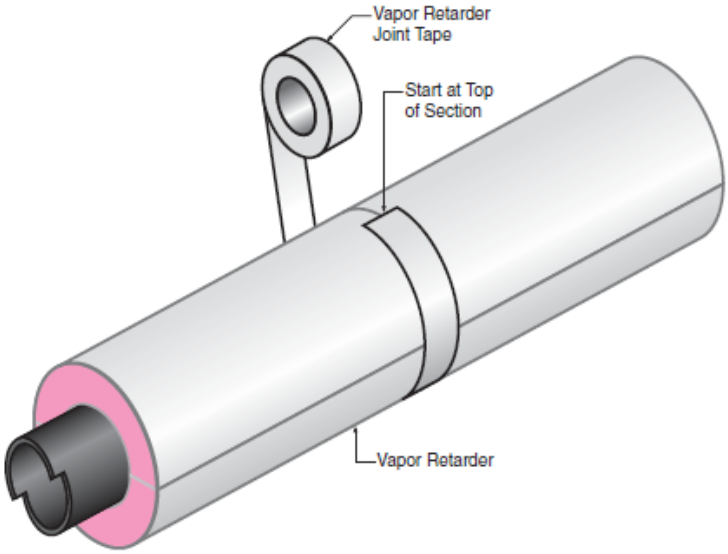
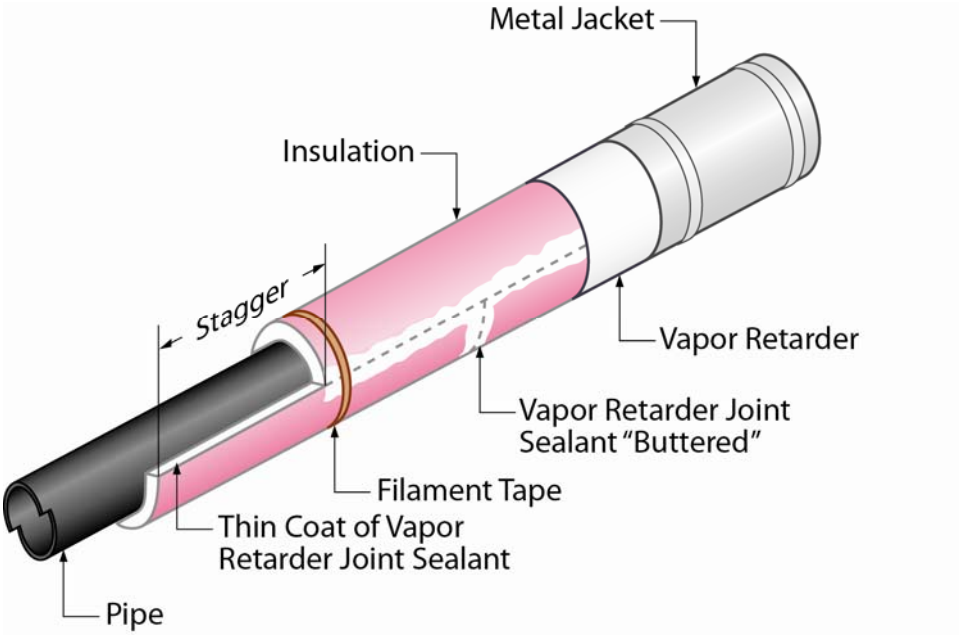


Figure 6

Insulation Details:

- Vapor retarder joint tape at butt joints shall be 3 inched wide.
- Wrap tape around butt joint a minimum of 1-1/4 times the circumference. Start tape at the top of the section to create a downward overlap to shed dirt and moisture.

Single Layer Installation – Vapor Retarder and Protective Jacket



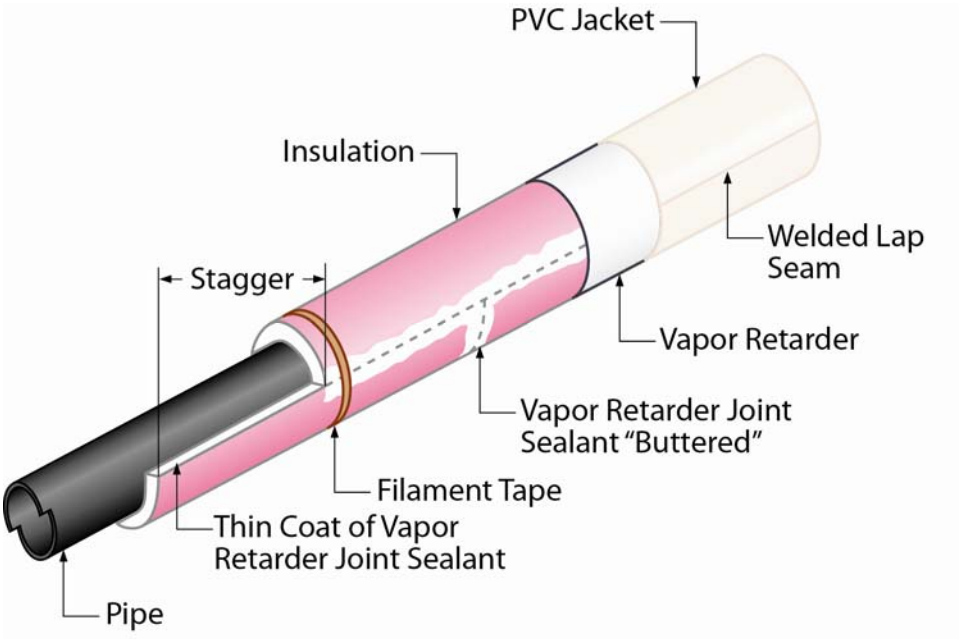


Figure 7

Insulation Details:

- Joint sealant is "buttered" on all longitudinal and butt joints.
- Stagger bottom and top half rounds of segments as shown if vapor retarder is field applied.
- Use thin coat of sealant over entire joint depth. Butter excess over face of joint as shown.
- Use ¾" filament tape to hold sections in place.

Single Layer Installation – Pipe Hanger Support

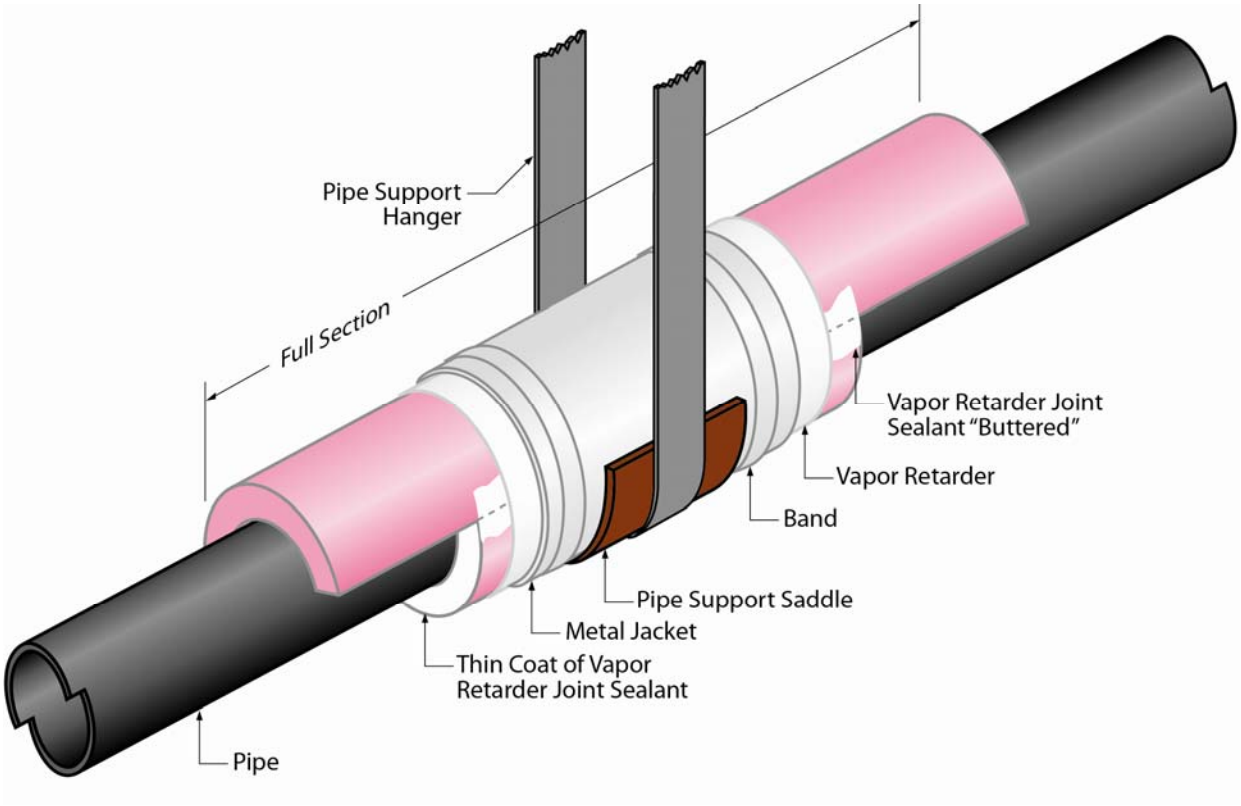


Figure 8

Insulation Details:

- Use appropriate compressive strength pipe insulation on bottom of pipe in the pipe hanger saddle based on pipe diameter, pipe material and hanger spacing.
- Vapor retarder and jacketing to be installed in a continuous fashion through the support.

Single Layer Installation – Expansion / Contraction Joint

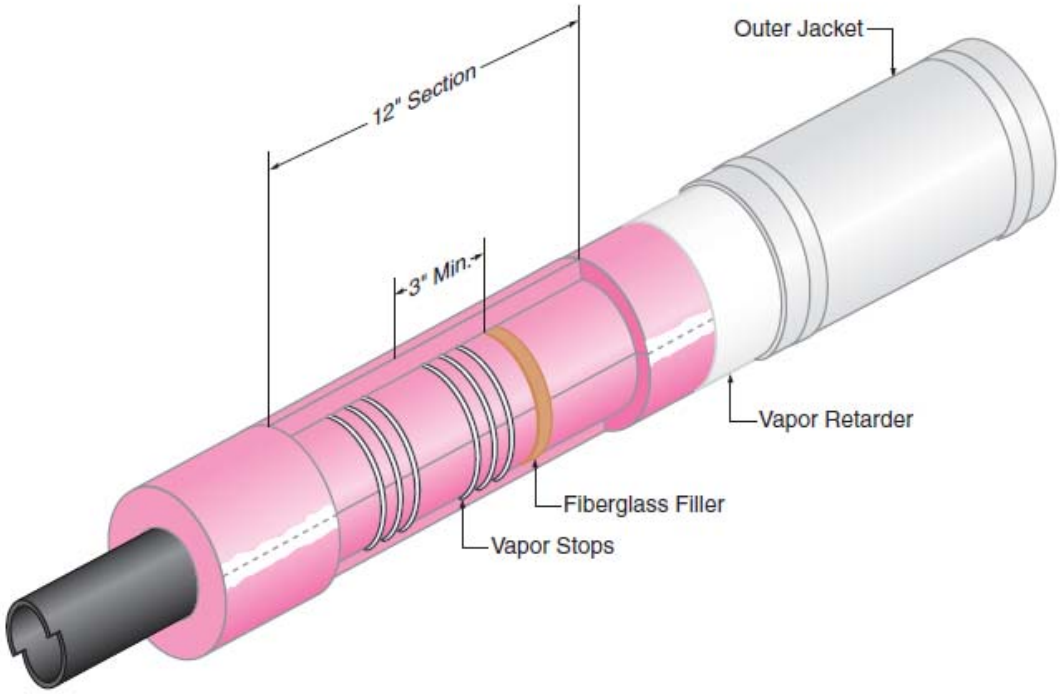
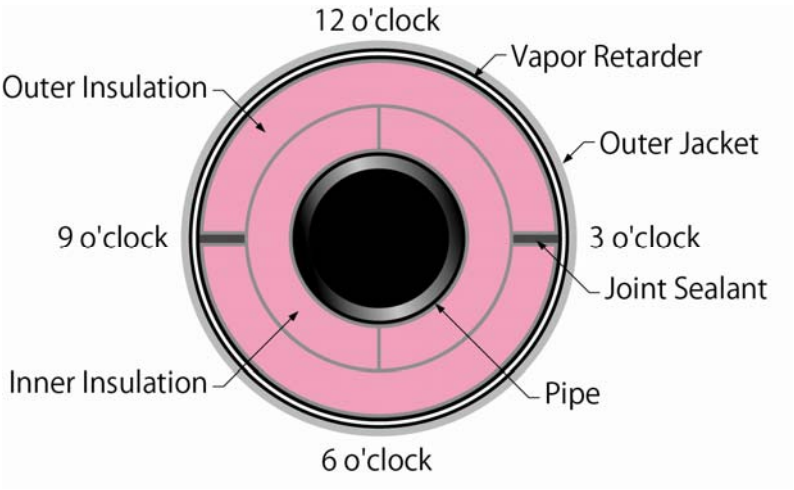


Figure 9

Insulation Details:

- Use in single layer insulation systems that require expansion joints.
- Allow sealant beads to cure before installation of outer layer.
- Place fiberglass filler in expansion joint of inner layer.
- After installation of fiberglass filler, force sections on either side of joint tightly together.

Double Layer Installation – Section Alignment and Joint Sealer



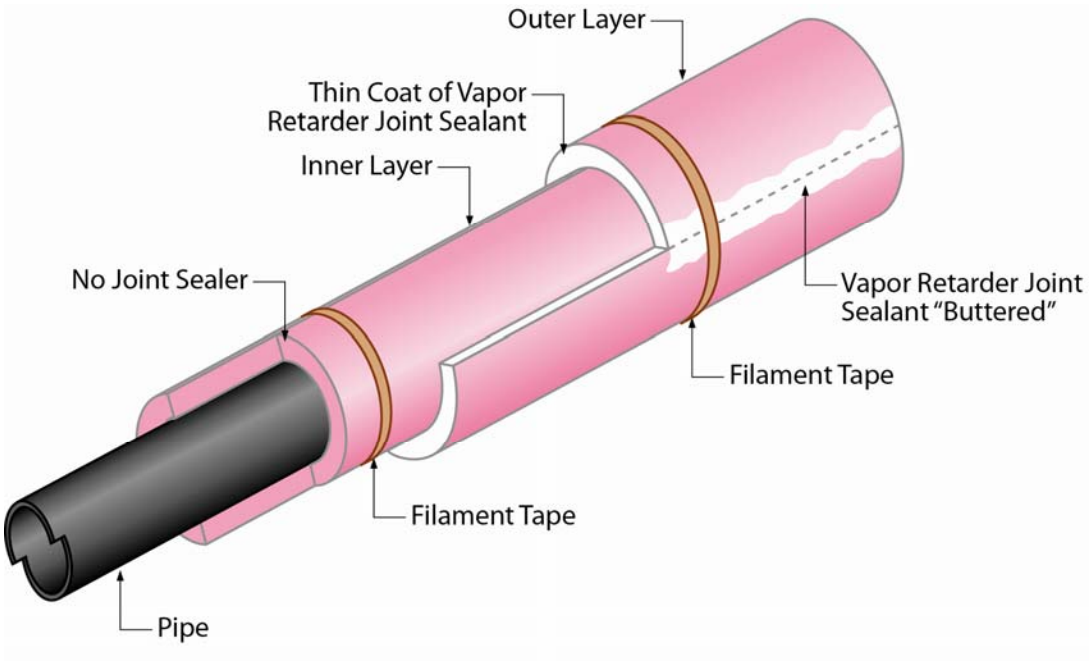


Figure 10

Insulation Details:

- Joint sealant is "buttered" on all longitudinal and butt joints of outer layer.
- Orient inner layer longitudinal joints at 12 O'clock and 6 O'clock and outer layer longitudinal joints at 3 O'clock and 6 O'clock. (Figure C).
- Stagger half round segments on each layer and between then inner and outer layers as shown.
- Use thin coat of sealant over entire joint depth. Butter excess over face of joint as shown.

Double Layer Installation – Double Layer Pipe Hanger Support

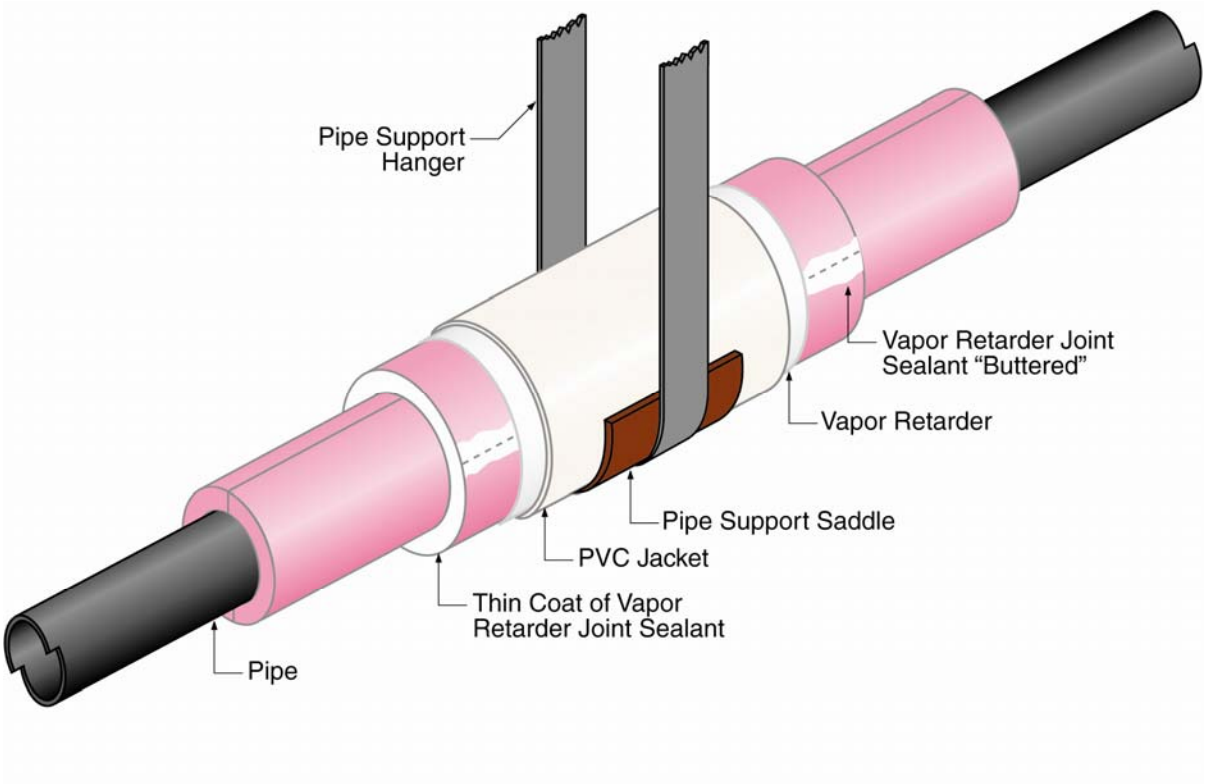


Figure 11

Insulation Details:

- Use appropriate compressive pipe insulation on bottom of pipe in the pipe hanger saddle based on pipe diameter, pipe material and hanger spacing.
- Vapor retarder and jacketing to be installed in a continuous fashion through the support.

Double Layer Installation – Shiplap Pipe Hanger Support

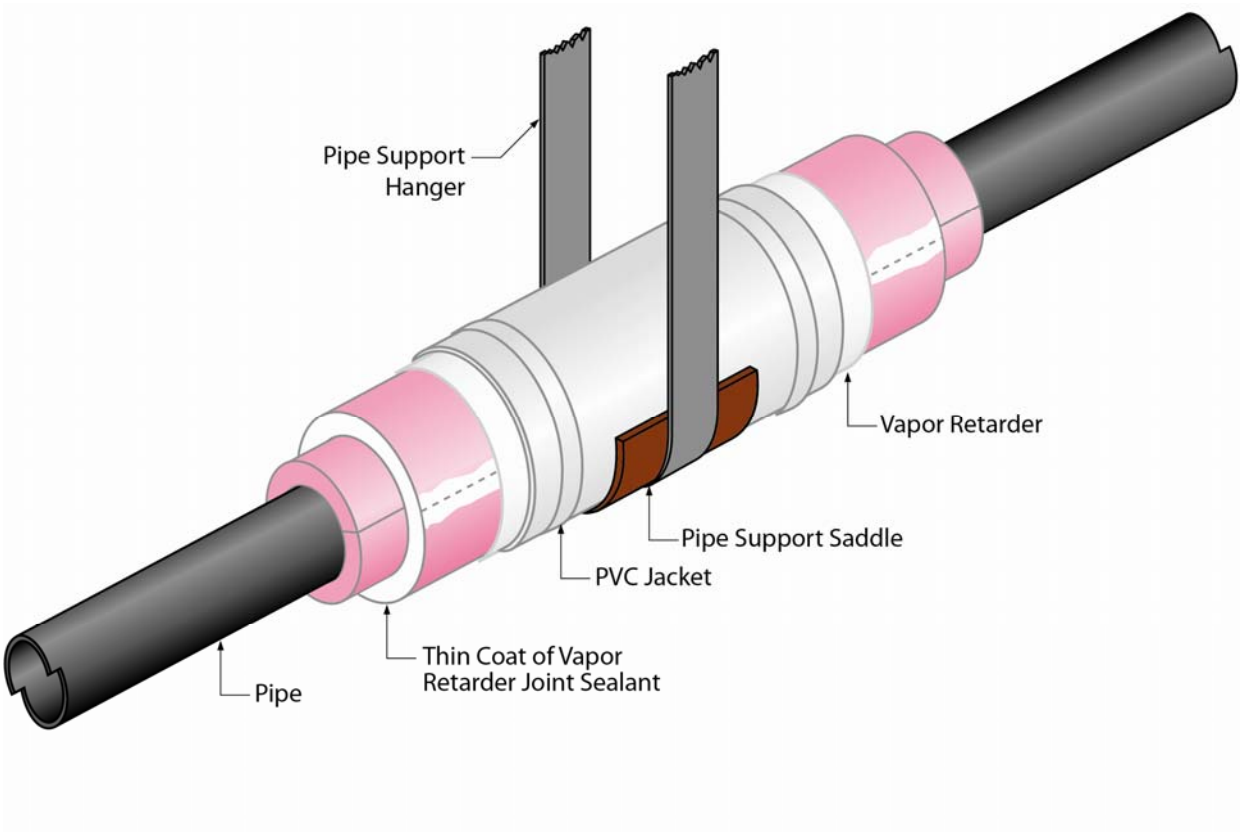


Figure 12

Insulation Details:

- Use appropriate compressive pipe insulation on bottom of pipe in the pipe hanger saddle based on pipe diameter, pipe material and hanger spacing.
- Vapor retarder and jacketing to be installed in a continuous fashion through the support.
- Shiplap end cuts on prefabricated full thickness sections cut to match the inner and outer layer of insulation.
- Use prefabricated single layer section with shiplap ends in lieu of double layer sections.

Double Layer Installation - Shiplap Insulation Fittings

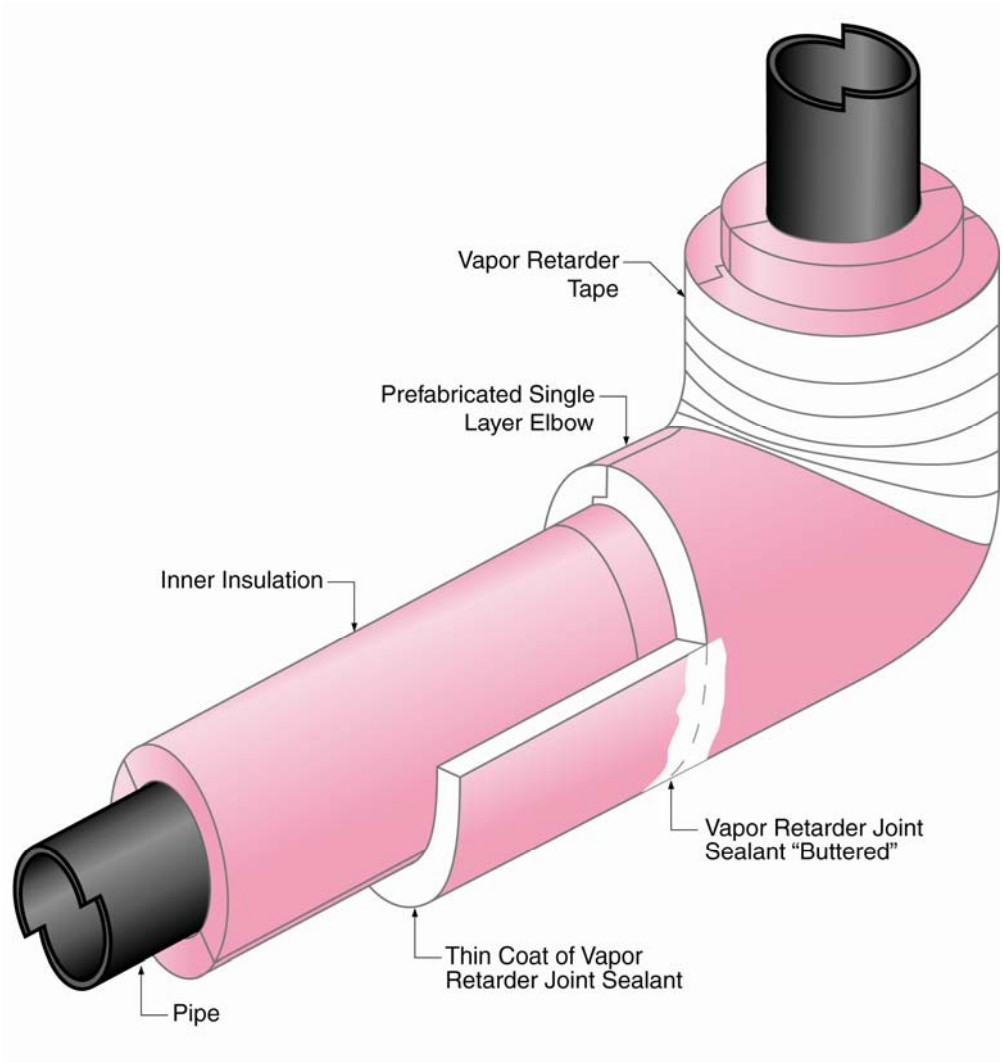


Figure 13

Insulation Details:

- Shiplap end cut on prefabricated fittings cut to match the inner and outer layer of insulation.
- Use prefabricated single layer fitting with shiplap end in lieu of double layer fittings.

Double Layer Insulation – Expansion / Contraction Joint

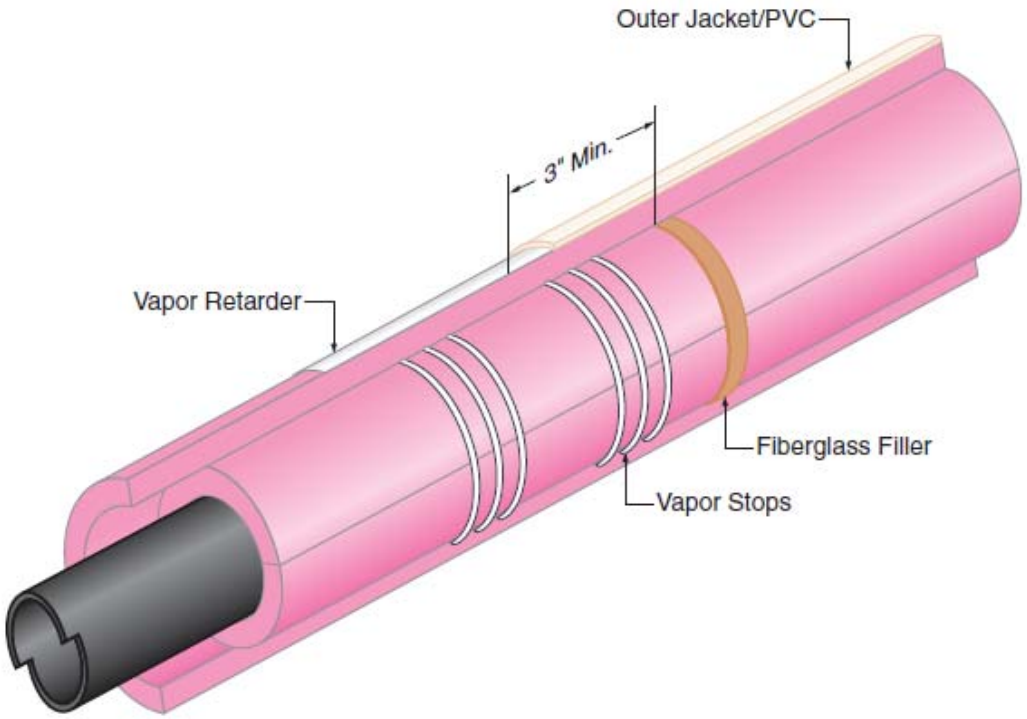


Figure 14

Insulation Details:

- Allow sealant beads to cure before installation of outer layer.
- Place fiberglass filler in expansion joint of inner layer.
- After installation of fiberglass filler, force sections on either side of joint tightly together.

Tank Head Installation

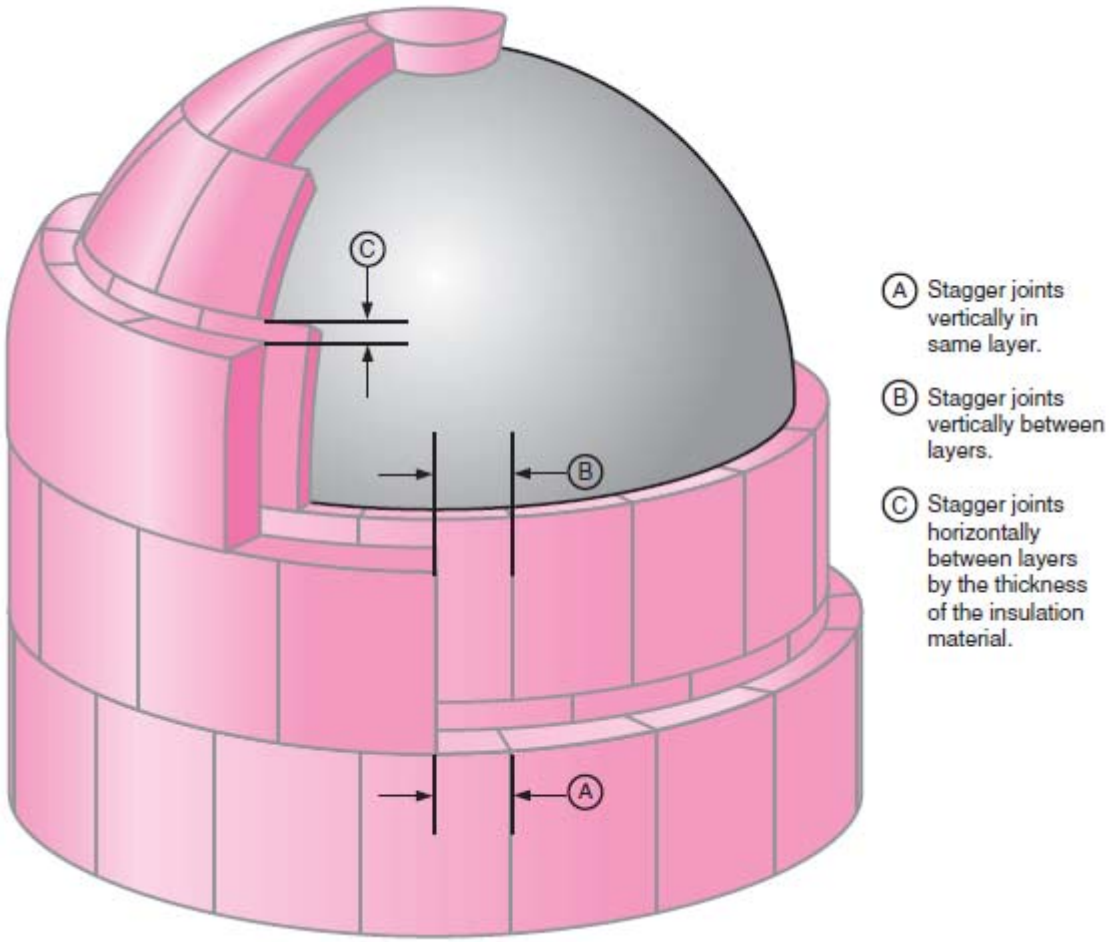


Figure 15

Insulation Details:

- 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.

APPENDIX B

ASTM C450 Section 7.2

		Customary Units for Insulation, Nominal Thickness								
		1	1½	2	2½	3	3½	4	4½	5
	NPS	Outer Diameter, in.								
0 Joints	½	2.88	4	5	6.62	7.62	8.62	9.62	10.75	11.75
	¾	2.88	4	5	6.62	7.62	8.62	9.62	10.75	11.75
	1	3.5	4.5	5.56	6.62	7.62	8.62	9.62	10.75	11.75
	1¼	3.5	5	5.56	6.62	7.62	8.62	9.62	10.75	11.75
	1½	4	5	6.62	7.62	8.62	9.62	10.75	11.75	12.75
1 Joint	2	4.5	5.56	6.62	7.62	8.62	9.62	10.75	11.75	12.75
	2½	5	6.62	7.62	8.62	9.62	10.75	11.75	12.75	14
	3	5.56	6.62	7.62	8.62	9.62	10.75	11.75	12.75	14
	3½	6.62	7.62	8.62	9.62	10.75	11.75	12.75	12.75	14
	4	6.62	7.62	8.62	9.62	10.75	11.75	12.75	14	15
	4½	7.62	8.62	9.62	10.75	11.75	12.75	14	14	15
	5	7.62	8.62	9.62	10.75	11.75	12.75	14	15	16
2 Joints	6	8.62	9.62	10.75	11.75	12.75	14	15	16	17
	7	—	10.75	11.75	12.75	14	15	16	17	18
	8	—	11.75	12.75	14	15	16	17	18	19
3 Joints	9	—	12.75	14	15	16	17	18	19	20
	10	—	14	15	16	17	18	19	20	
	11	—	15	16	17	18	19	20		
	12	—	16	17	18	19	20			
4 Joints	14	—	17	18	19	20				

The above chart can be used to assist the designer/specifier in meeting ASTM C450, of no more than four cemented through joints in a full section.

Design Table for Ammonia Refrigeration Outdoors

ambient temp. = 100°F
ambient relative humidity = 90%
dewpoint - 97°F
outer surface = metal (E = 0.4)
wind velocity = 7.5 mph
geometry = horizontal pipe

	Service Temperature (°F)							
Nominal Pipe Size	-100	-80	-60	-40	-20	0	20	40
0.5	3	3	2.5	2	2	2	2	1.5
0.75	3.5	3	3	2.5	2	2	2	2
1	3.5	3.5	3	3	2.5	2	2	2
1.25	3.5	3.5	3.5	3	2.5	2.5	2	2
1.5	3.5	3.5	3.5	3	2.5	2.5	2	2
2	4	3.5	3.5	3.5	3	2.5	2	2
2.5	4	3.5	3.5	3.5	3	2.5	2	2
3	4.5	4	4	3.5	3.5	3	2	2
4	5	4.5	4	3.5	3.5	3	2.5	2
5	5.5	5	4.5	4	3.5	3.5	2.5	2
6	5.5	5	4.5	4	3.5	3.5	3	2
8	5.5	5.5	5	4.5	4	3.5	3	2.5
10	6	5.5	5.5	5	4	3.5	3	2.5
12	6	5.5	5.5	5	4.5	3.5	3.5	2.5
14	6.5	6	5.5	5	4.5	4	3.5	2.5
16	6.5	6	5.5	5.5	4.5	4	3.5	3
18	6.5	6	5.5	5.5	5	4	3.5	3
20	7	6.5	5.5	5.5	5	4	3.5	3
Tank Side	7	6.5	6	5.5	5	4	3.5	2.5
Tank Top	6	5.5	5.5	4.5	4	3.5	3	2
Tank Bottom	9.5	8.5	8	7	6.5	5.5	4.5	3.5

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

Design Table for Ammonia Refrigeration Indoors

ambient temp. = 90°F
ambient relative humidity = 80%
dewpoint - 83°F
outer surface = PVC (E = 0.9)
wind velocity = 0 mph
geometry = horizontal pipe

	Service Temperature (°F)							
Nominal Pipe Size	-100	-80	-60	-40	-20	0	20	40
0.5	2	2	2	2	2	1.5	1.5	1
0.75	2	2	2	2	2	2	1.5	1
1	2.5	2	2	2	2	2	1.5	1.5
1.25	2.5	2.5	2.5	2	2	2	1.5	1.5
1.5	2.5	2.5	2.5	2	2	2	1.5	1.5
2	3	2.5	2.5	2	2	2	1.5	1.5
2.5	3	2.5	2.5	2	2	2	1.5	1.5
3	3	3	2.5	2.5	2	2	2	1.5
4	3	3	2.5	2.5	2	2	2	1.5
5	3.5	3	3	2.5	2.5	2	2	1.5
6	3.5	3.5	3	2.5	2.5	2	2	1.5
8	3.5	3.5	3	3	2.5	2	2	1.5
10	3.5	3.5	3	3	2.5	2	2	1.5
12	3.5	3.5	3.5	3	2.5	2	2	1.5
14	3.5	3.5	3.5	3	2.5	2	2	1.5
16	4	3.5	3.5	3	2.5	2	2	1.5
18	4	3.5	3.5	3	2.5	2.5	2	1.5
20	4	3.5	3.5	3	3	2.5	2	1.5
Tank Side	4.5	4	3.5	3.5	3	2.5	2	1.5
Tank Top	4.5	4	3.5	3.5	3	2.5	2	1.5
Tank Bottom	4.5	4	3.5	3.5	3	2.5	2	1.5

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

Design Table for an Installation Inside a Cold Storage Room

ambient temp. = 40°F — outer surface = PVC (E = 0.9)
ambient relative humidity = 90% — wind velocity = 0 mph
dewpoint - 37°F — geometry = horizontal pipe

	Service Temperature (°F)						
Nominal Pipe Size	-100	-80	-60	-40	-20	0	10
0.5	3.5	2.5	2.5	2	2	2	1.5
0.75	3.5	3	3	2.5	2	2	1.5
1	4	3.5	3.5	2.5	2	2	1.5
1.25	4	3.5	3.5	3	2	2	1.5
1.5	4	3.5	3.5	3	2	2	2
2	4.5	3.5	3.5	3.5	2.5	2	2
2.5	5	4	3.5	3.5	2.5	2	2
3	5.5	4	4	3.5	3	2	2
4	5.5	4.5	4	3.5	3	2	2
5	5.5	5	4.5	3.5	3	2	2
6	6	5.5	4.5	3.5	3.5	2.5	2
8	6	5.5	5	4	3.5	2.5	2
10	6.5	5.5	5.5	4	3.5	2.5	2
12	7	5.5	5.5	4.5	3.5	2.5	2
14	7	6	5.5	4.5	3.5	2.5	2
16	7	6	5.5	4.5	3.5	3	2
18	7	6.5	5.5	5	3.5	3	2
20	7	6.5	5.5	5	4	3	2
24	7.5	7	6	5	4	3	2

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

Design Table for Very Harsh Outdoors

ambient temp. = 90°F
ambient relative humidity = 90%
dewpoint - 87°F
outer surface = metal (E = 0.4)
wind velocity = 7 mph
geometry = horizontal pipe

	Service Temperature (°F)								
Nominal Pipe Size	-100	-80	-60	-40	-20	0	20	40	60
0.5	3.5	3	2.5	2.5	2	2	2	1.5	1
0.75	3.5	3.5	3	2.5	2	2	2	1.5	1
1	3.5	3.5	3.5	3	2.5	2	2	1.5	1
1.25	3.5	3.5	3.5	3	3	2.5	2	1.5	1.5
1.5	3.5	3.5	3.5	3	3	2.5	2	2	1.5
2	4	4	3.5	3.5	3	2.5	2	2	1.5
2.5	4	4	3.5	3.5	3	2.5	2	2	1.5
3	4.5	4.5	4	3.5	3.5	3	2.5	2	1.5
4	5	4.5	4	3.5	3.5	3	2.5	2	1.5
5	5.5	5	4.5	4	3.5	3.5	2.5	2	1.5
6	5.5	5.5	4.5	4	3.5	3.5	3	2	1.5
8	6	5.5	5	4.5	4	3.5	3	2	1.5
10	6	5.5	5.5	5	4	3.5	3	2	1.5
12	6.5	6	5.5	5	4.5	3.5	3	2.5	1.5
14	7	6	5.5	5.5	4.5	4	3.5	2.5	2
16	7	6.5	5.5	5.5	4.5	4	3.5	2.5	2
18	7	6.5	6	5.5	5	4	3.5	2.5	2
20	7	6.5	6	5.5	5	4	3.5	2.5	2
24	7	7	6	5.5	5	4	3.5	2.5	2
30	7.5	7	6.5	5.5	5	4.5	3.5	2.5	2
36	7.5	7	6.5	5.5	5.5	4.5	3.5	3	2

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

Design Table for Indoors, High Humidity, Narrow Temp Range

ambient temp. = 70°F — outer surface = PVC (E = 0.9)
ambient relative humidity = 90% — wind velocity = 0 mph
dewpoint - 67°F — geometry = horizontal pipe

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

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

Design Table for Indoors, Harsh Conditions

ambient temp. = 90°F
ambient relative humidity = 90%
dewpoint - 87°F
outer surface = PVC (E = 0.9)
wind velocity = 0 mph
geometry = horizontal pipe

	Service Temperature (°F)								
Nominal Pipe Size	-100	-80	-60	-40	-20	0	20	40	60
0.5	3.5	3	3	2.5	2	2	2	1.5	1
0.75	3.5	3.5	3	2.5	2.5	2	2	2	1.5
1	3.5	3.5	3.5	3	2.5	2	2	2	1.5
1.25	3.5	3.5	3.5	3.5	3	2.5	2	2	1.5
1.5	3.5	3.5	3.5	3.5	3	2.5	2	2	1.5
2	4	4	3.5	3.5	3	2.5	2	2	1.5
2.5	4	4	3.5	3.5	3	2.5	2	2	1.5
3	4.5	4.5	4	3.5	3.5	3	2.5	2	1.5
4	5	4.5	4	3.5	3.5	3	2.5	2	1.5
5	5.5	5	4.5	4	3.5	3.5	2.5	2	1.5
6	5.5	5	4.5	4	3.5	3.5	3	2	1.5
8	5.5	5.5	5	4.5	4	3.5	3	2	1.5
10	6	5.5	6.6	4.5	4	3.5	3	2	1.5
12	6	5.5	6.6	5	4	3.5	3	2	1.5
14	6.5	6	5.5	5	4.5	3.5	3.5	2.5	2
16	6.5	6	5.5	5.5	4.5	3.5	3.5	2.5	2
18	7	6	5.5	5.5	4.5	4	3.5	2.5	2
20	7	6.5	5.5	5.5	4.5	4	3.5	2.5	2
24	7	6.5	6	5.5	5	4	3.5	2.5	2
30	7	7	6	5.5	5	4	3.5	2.5	2
36	7	7	6.5	5.5	5	4	3.5	2.5	2
48	7.5	7	6.5	5.5	5.5	4.5	3.5	2.5	2

This table is based on the ASTM C 680 algorithm for thickness of insulation required to control condensation on the outer surface of an insulated pipe, as used in the NAIMA 3E PLUS program. The required insulation thickness values do not include a safety factor. Actual operating conditions can vary. Consult a design engineer for an appropriate safety factor. The chart was developed with a K factor of 0.200 at 180 days at 75 degrees mean temperature.

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