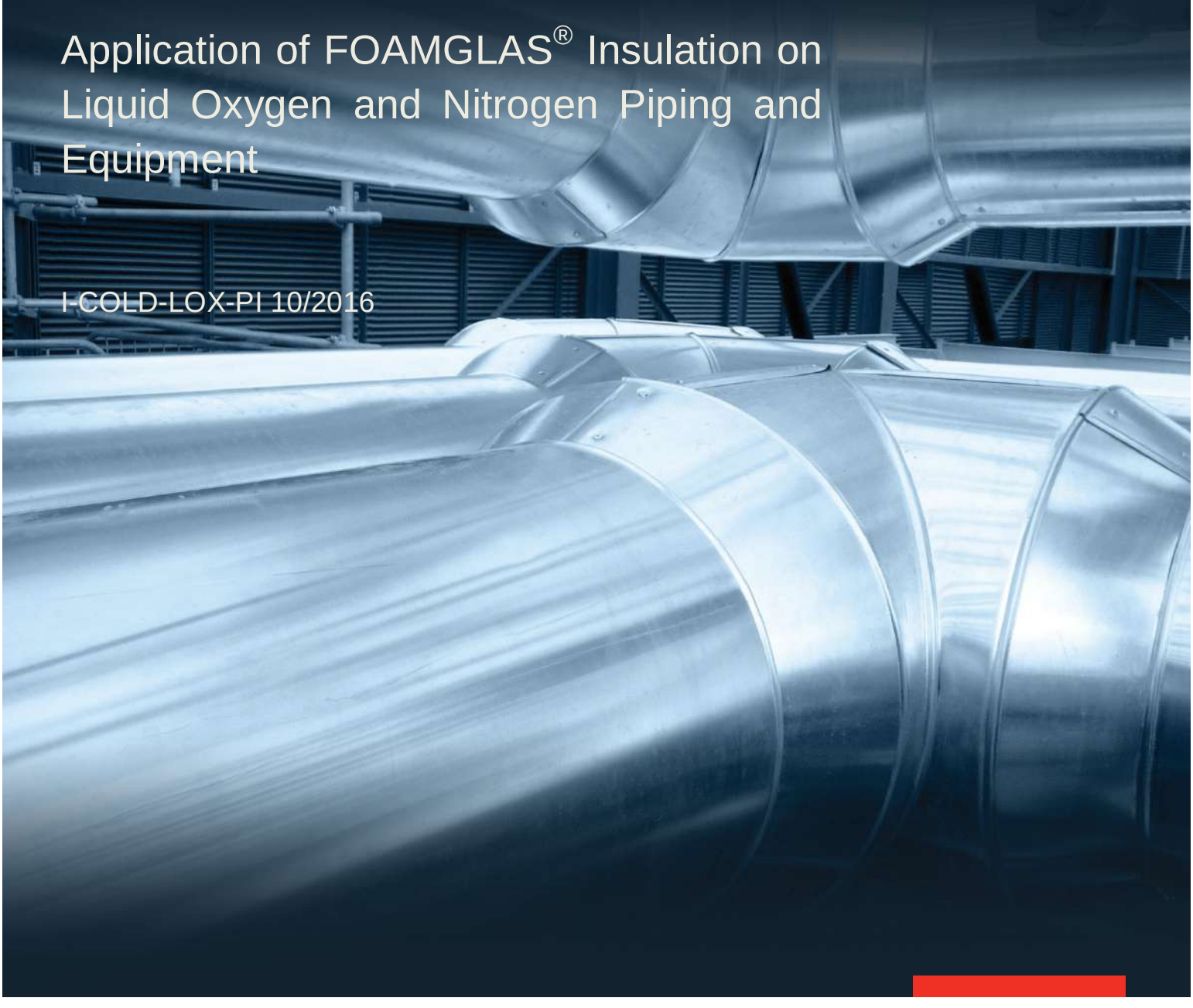
FOAMGLAS® INSULATION SYSTEM SPECIFICATION

FOAMGLAS
Pittsburgh Corning

Application of FOAMGLAS® Insulation on Liquid Oxygen and Nitrogen Piping and Equipment



I-COLD-LOX-PI 10/2016

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1. General Notes

1.1 This specification covers the application of FOAMGLAS® insulation to liquid oxygen or similar piping and equipment operating at temperatures between -200°C and -180°C (-328°F and -292°F). While all components may not be LOX compatible, attempts have been made to limit organic materials in the regions of insulation where LOX might condense out of the air. This specification may be applicable for indoor or outdoor installations. This specification is valid as for pre-insulation and on-site installation. Additional requirements for the insulation system, such as fire protection and/or acoustic insulation, will be covered by additional specifications or specification attachment.

1.2 Any deviation from this specification (i.e. alternative accessory materials, design etc.) must be authorized by written approval.

1.3 The product data sheets referenced in the text are listed at the end of the specification. Product data sheets for Pittsburgh Corning products may be accessed on line at: www.foamglas.com .

1.4 Technical drawings addressing most details are provided in Appendix A. Contact Pittsburgh Corning if additional details are needed.

1.5 SI and Metric unit conversions have been rounded to nearest English unit equivalent.

2. Codes and Standards

2.1 AISI American Iron and Steel Institute

2.2 ASTM International Standards

2.2.1 ASTM C552 Standard Specification for Cellular Glass Thermal Insulation

2.2.2 ASTM C1639 Standard Specification for Fabrication of Cellular Glass Pipe and Tubing Insulation

2.2.3 ASTM C1729 Standard Specification for Aluminum Jacketing for Insulation

2.2.4 ASTM C1767 Standard Specification for Stainless Steel Jacketing for Insulation

2.2.5 ASTM E136 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

2.3 EN Standards

2.3.1 EN 14305, Thermal insulation products for building equipment and industrial installations. Factory made cellular glass (CG) products. Specification

2.3.2 EN ISO 1182, Reaction to fire tests for building products — Non-combustibility test (ISO 1182:2002)

2.3.3 EN ISO 9229, Thermal insulation — Vocabulary (ISO 9229:2007)

2.4 International Organization for Standardization (ISO)

2.5 ISO 9001: Quality management systems — Requirements

2.5.1 ISO 9002: Quality systems. Modelled for quality assurance in production, installation, and servicing.

2.6 United States Coast Guard International Maritime Organization (USCG IMO)

2.6.1 Coast Guard Approval Number: 164.109/55/0

2.7 British Standards (BS)

2.7.1 BS 4370-1-4 Method of test for rigid cellular materials

2.8 German Standards (DIN)

2.8.1 DIN 4102-1 Fire Behaviour of Building Materials and Building Components. Section 6.2 – Building Materials of Class B2

3. Preliminary Conditions

3.1 FOAMGLAS® pipe insulation and fabricated fittings must be transported and stored vertically. Packages must be handled with care and protected from the elements while in storage. FOAMGLAS® insulation packages and must not be allowed to come into direct contact with the ground in to prevent possible damage or contamination prior to application.

3.2 The surface to be insulated must be clean and free from all traces of grease, rust, dust and any foreign matter. The design engineer must decide whether a protective coating system is necessary, and to also determine if the system is compatible with the service temperature. If the engineer decides to specify an anti-corrosion product, the following rules must be observed:

3.2.1 The specifying engineer or owner shall at their option designate a rust inhibitor or corrosion resistant paint to be applied before the application of any insulation. The application of such paint or coating is not a requirement of this specification.

3.2.2 Any surface imperfection must be cleaned with a wire brush and then coated with a new layer of anti-corrosion paint or other suitable product. The surface must be moisture free before the insulation is applied and the product application must follow the anti-corrosion product manufacturer's guidelines.

3.2.3 When an adhesive is used, the compatibility between the anticorrosion paint and the adhesive must be verified before applying the insulation.

3.3 The surface and the materials used must be dry before and during application, and must remain dry until start-up of the insulated system.

3.4 The application of FOAMGLAS® insulation on pipes or equipment is to be done at ambient temperature.

3.5 The temperature limits of the accessory products must be respected during both storage and application.

3.6 Hydrostatic, radiographic and other tests must be completed before the insulation is applied in order to assure proper system performance.

4. Design Requirements

4.1 The heat transfers should be limited to acceptable values with respect to both economic and functional aspects. Design thickness criteria will limit heat gain to between 25 to 37 W/m^2 (8 to 12 $Btu/hr•ft^2$). In some cases this may also limit condensation (recommendable). The insulation thickness shall be determined through calculations based on particular and unique environmental and operating conditions.

4.2 The insulation thickness shall be calculated in accordance to ISO 12241, or ASTM C680, and based upon project requirements for heat loss, environmental conditions, etc.

4.3 Piping and equipment shall be insulated according to insulation class, operating temperature and insulation thickness defined in the specifications, P&ID, line designation table (list), piping isometrics, equipment drawings, general arrangement drawings, insulation thickness tables.

4.4 The entire system shall be fully insulated, including all piping components, instruments and tubing, drains to the extent specified.

4.4.1 All metal parts that protrude through the insulation shall be insulated, over an extent of 3 times the insulation thickness.

4.5 The insulation at pipes and equipment shall end in such a distance to adjacent flanges, to allow removal of bolts without damage to the insulation.

4.5.1 Nameplates and tags shall be insulated; vessel vendor shall provide a duplicate, to be installed by insulation contractor on the outside surface of the insulation.

5. Materials Used

5.1 Insulation material - Insulation shall be FOAMGLAS® cellular glass insulation manufactured in accordance with ASTM C552, "Standard Specification for Cellular Glass Thermal Insulation", by Pittsburgh Corning whose quality system for manufacturing, inspecting, and testing of FOAMGLAS® insulation is certified to meet the requirements of ISO 9001:2008. FOAMGLAS® pipe insulation shall be fabricated according to the requirements of ASTM C1639 "Standard Specification for Fabrication of Cellular Glass Pipe and Tubing Insulation". Hydrocal® B-11, PC® 80M Mortar, or PCE HTAA cement shall be used as fabricating adhesive and bore coating for FOAMGLAS® insulation for pipe and fittings when used on systems operating at temperature below -183°C (-297°F). Fabrication shall be such that insulation through joints are minimized.

5.2 Anti-abrasive - This coating is only to be applied if the piping will be submitted to frequent and significant thermal movements or to vibrations. The anti-abrasive coating must be applied onto the inner side of the FOAMGLAS® elements which will be in contact with the metal pipe or equipment.

5.2.1 PC® HTAA supplied by Pittsburgh Corning.

5.2.2 PC® 80M Mortar available from Pittsburgh Corning. PC® 80M Mortar is a two-component in inorganic, non-combustible bore coating that is acceptable for use with stainless steel.

5.2.3 Hydrocal® B 11 gypsum cement, manufactured by U.S. Gypsum Corporation.

5.3 Joint sealant shall be one of the following:

5.3.1 PITTSEAL® 444N^{s} sealant or PITTSEAL® 444N sealant supplied by Pittsburgh Corning. PITTSEAL® 444N^{s} sealant and PITTSEAL® 444N sealant are specially formulated butyl sealant used for sealing joints in FOAMGLAS® insulation systems.

5.3.2 PC® RTV 450 Silicone Adhesive supplied by Pittsburgh Corning. A one part, neutral cure, silicone adhesive/sealant formulated for use with FOAMGLAS® insulation.

5.4 Vapor Stop Sealant shall be PITTSTOP™ 196 Vapor Stop supplied by Pittsburgh Corning. PITTSTOP™ 196 Vapor Stop is a two component 1:1 mix ratio butyl rubber elastomer specially designed for use as a vapor stop sealant/coating/adhesive for cryogenic systems.

5.5 Cryogenic adhesive shall be PC® 42 Cryogenic Adhesive supplied by Pittsburgh Corning. PC® 42 Cryogenic Adhesive is a three component, cryogenic adhesive formulated for use with FOAMGLAS® insulation.

5.6 Contraction joint filler/cushioning blankets, if necessary, shall be Type E needled glass fiber felt thermal insulation containing no organic binders, manufactured in accordance with ASTM C1086, or light density (48 kg/m^3 or 3 lb./ft^3) fiberglass.[1]

5.7 Contraction joint vapor barrier/contraction joint barrier sheet shall be one of the following:[1]

5.8 Minimum 1.6 mm (0.062 in.) thick solid neoprene or butyl rubber

5.8.1 Minimum 0.94mm (0.037 in.) thick silicone impregnated glass fabric

[1] Product manufacturer information available in Appendix B

5.9 Tape shall be a high tensile strength, fiber reinforced tape or equivalent.[1]

5.10 Metal Bands shall be AISI type 304 (BSI 304 S16) stainless steel, 13 mm wide x 0.4 mm thick (0.5 in. x 0.016 in.), with matching seals or aluminum bands with matching seals, 13 x 0.5 mm (0.5 in. x 0.020 in.) for piping and equipment with O.D. up to 1219mm (48 in.), 19 x 0.5 mm (0.75 in. x 0.020 in.) for larger O.D.

5.11 Reinforcing mesh fabric for the vapor retarder coating shall be one of the following:

5.11.1 Synthetic fabric, 6.5 x 6 meshes, PC® Fabric 79 as supplied by Pittsburgh Corning or approved equal.

5.11.2 Glass reinforcing mesh, PC® 150 glass reinforcing mesh as supplied by Pittsburgh Corning or approved equal.

5.12 Protective coatings, membranes, or finishes will be installed to serve as a vapor retarder. This material will fill the surface cells of the FOAMGLAS® insulation to improve mechanical resistance of the system, improve freeze-thaw protection of the system, and to serve as an additional barrier to vapor and liquids. The protective coating, membrane, or finish shall be:

5.12.1 PITTWRAP® B100 jacketing supplied by Pittsburgh Corning, a 1.2 mm, (47 mil) thick Aluminum/butyl jacketing or equivalent.

5.12.2 Terostat PC® FR silicone polymer coating, as supplied by Pittsburgh Corning.

5.12.3 PITTCOTE® 300 coating supplied by Pittsburgh Corning. A vapor retarder asphalt coating especially formulated for use with FOAMGLAS® insulation. PITTCOTE® 300 finish must be reinforced with a synthetic or glass fabric mesh, and must be covered with a metal jacket.

5.12.4 Hypalon® based coating (type Monolar® or similar), to be reinforced with synthetic fabric, as PC® Fabric 79 or similar.

5.13 Metal jacket finish for mechanical or fire protection shall be one of the following:

5.13.1 Use minimum 0.4mm (0.016 in.) aluminum jacket for insulation O.D.'s of 610mm (24 in.) or less. For larger O.D.'s use 0.6mm (0.024 in.). Aluminum jacket. Aluminum jacketing shall conform to ASTM C1729 Standard Specification for Aluminum Jacketing for Insulation.

5.13.2 Use minimum 0.4 mm (0.016 in.) smooth steel (i.e. stainless galvanized, aluminized, galvalume, etc.) where the FOAMGLAS® insulation system is also being used for fire protection. Stainless steel jacketing shall conform to ASTM C1767 Standard Specification for Stainless Steel jacketing for Insulation.

[1] Product manufacturer information available in Appendix B

6. Application of Pipe Insulation

6.1 Before application of the insulation:

6.1.1 Apply vapor stop system to cryogenic supports (when required)

6.1.2 Mark location of insulation terminations (at flanges, valves …) and contraction joint location (when required) on the object.

6.1.3 The insulation of straight piping, bends, T-pieces, equipment heads will be fully fabricated following applicable standards before installation to fit the piping using the fewest number of pieces as possible, and defined by transport conditions. Fabrication of fittings has to be designed as such that longitudinal and circumferential joints in the different layers are staggered.

6.2 The insulation application should include the following procedures:

6.2.1 It is necessary to install the insulation in two or more layers. Two layers will normally suffice, when respective FOAMGLAS® insulation thicknesses are commercially available. The first layer of insulation will increase the surface temperature to the lower temperature limit of the PITTSEAL® 444N^{S} or 444N sealant.

6.2.2 The insulation of straight piping, bends, T-pieces, equipment heads will be fully fabricated to fit the piping using the fewest number of pieces as possible, and defined by transport conditions.

6.2.3 It is strongly recommended to start the application of the insulation at the fittings. Straight sections of pipes will be insulated after the fittings since these regions are easily insulated by cutting the insulation on site to fit between fittings/marks.

6.2.4 The first layer of FOAMGLAS® insulation shall be installed dry (using no joint sealant). The first layer shall be secured with fiber reinforced tape applied on 300 mm (12 in.) centers, with a 50% overlap of the tape per wrap, or with metal bands.

6.2.5 Intermediate layers of FOAMGLAS® insulation (if required) shall be applied using no joint sealant, with all joints staggered from those of the preceding layer. Securement of each layer shall be with fiber reinforced tape using two (2) wraps per section or with metal bands.

6.2.6 The final layer of insulation shall be applied with all joints staggered from those of the preceding layer and sealed with joint sealer. A continuous seal must be provided for the full length of all joints. Care should be taken to ensure that sealant in the longitudinal and circumferential joints meet in order to avoid sealant gaps. The application of sealant may be by extrusion (gun or cartridges) or bucket with a trowel or putty knife. Using a cartridge or applicator gun, the sealant is applied in beads of sufficient thickness to close the joint at installation. It is recommended to apply two beads in the circumferential joint. Alternatively the sealant may be applied full depth of the insulation thickness using a trowel or putty knife.

6.2.7 The outer layer of FOAMGLAS® insulation shall be secured with 13 mm wide x 0.4 mm thick (1/2 in. x .015 in.) stainless steel bands at the rate of two (2) bands, equally spaced, per section of insulation. Bands are to be well secured, closing tightly the longitudinal joints.

6.2.8 Care must be taken that the outer layer of FOAMGLAS® insulation is not cracked when secured with the stainless steel bands. Cracked or broken FOAMGLAS® insulation shall be replaced.

6.3 Expansion/contraction joints

6.3.1 General - Physical contraction of the pipes, when cooled down to cryogenic temperatures, may affect the insulation system, since differences in temperature and the expansion coefficients will result in the creation of gaps in many types of insulation and finishes, or in undue stress which can cause cracks in the insulation. FOAMGLAS® insulation has excellent dimensional stability, having an expansion coefficient lower than and closer to steel, than most other insulation materials. Thus when a pipe insulated with FOAMGLAS® insulation is cooled, the joints in the FOAMGLAS® insulation will have a tendency to tighten and therefore no gaps will be created. Steps must be taken to accommodate differential thermal contraction between the pipe and the outer layer of FOAMGLAS® insulation. As a guideline the differential contraction/expansion between the pipe and FOAMGLAS® insulation is roughly 2.3mm per meter (2.8 in. per 100 lineal feet). The amount of physical contraction/expansion of the piping and equipment shall be determined by the design engineer. The two options discussed below are the approved methods for accommodating thermal contraction/expansion with FOAMGLAS® insulation.

6.3.2 Option one – Joint sealant as contraction/expansion joints on horizontal piping

6.3.2.1 This system will only function using vapor retarders that are appropriate for this system. The recommended vapor retarders for this system are Terostat monomer coating, as supplied by Pittsburgh Corning or PITTWRAP® B100 Aluminum-butyl jacketing or equivalent.

6.3.2.2 In this application each sealed circumferential joint which occurs every 610 mm or 914mm (24 in. or 36 in.) becomes an expansion contraction joint. Circumferential joints in the outer layer will generally be 2 to 3 mm wide (0.12 in.). The sealant is applied in beads of sufficient thickness to close the joint at installation. Apply two beads in the circumferential joint (note that complete filling of joint will result in too excess sealant when closed at service). A 2mm (0.08 in.) thick spacer may be used for the application in order to ensure minimum joint width. This system is not applicable on vertical piping and equipment, as insulation weight will close joints.

6.3.3 Option two – Conventional contraction/ expansion joints on horizontal and vertical piping

6.3.3.1 At least one contraction joint is required every 9 m (30 ft.). In addition a contraction joint is required between two fixed points (i.e. supports, fittings, insulation terminations, etc.) when the distance between the fixed points exceeds 6 m (20 ft.). A contraction joint shall be installed to provide for a maximum contraction of 25mm (1 in.). Contraction joints are to be applied in all layers, minimum 150 mm (6 in.) offset, maximum width to be 50mm (2 in.), and filled with resilient low density fiberglass or mineral wool (orient the glass or mineral fibers in a direction perpendicular to the pipe). The rubber vapor barrier sheet is wrapped around the joint, completely sealed with joint sealer, and banded with stainless steel bands.

6.3.3.2 On vertical piping, expansion/contraction joints will be installed under the insulation support ring, under the pipe support and under the top elbow.

6.3.3.3 Contraction joints on vertical piping shall be installed at supports at a minimum of one every 9 m (30 ft.).

6.4 Valve and Flange insulation - Valves and flanges to be insulated applying the same thickness and layering as the adjacent piping.

6.4.1 The adjacent straight piping is provided a step-type juncture in order to allow insulation to be installed with staggered joints. Vapor stop mastic (if required) is applied to juncture in time to allow complete drying before box installation. It is recommended to insulate valves and flanges with prefabricated boxes made to fit. All voids between object and boxes to be filled with loose wool.

6.5 Vapor stop

6.5.1 Vapor stops shall be installed on all supports, all protrusions and all insulation terminations. The vapor stop is applied before the vapor retarder mastic/foil, and covers as well the metal surface, as the outer insulation surface. Vapor stop sealant and cryogenic adhesive shall be as specified in 5.4 and 5.5.

6.5.2 Follow the recommended mixing and application procedures on the product data sheets for the PC® 42 Cryogenic Adhesive and PITTSTOP™ 196 Vapor Stop, and the detail drawing in section 12.3 Appendix A3 for more information on proper vapor stop installation.

6.6 Miscellaneous

6.6.1 Vertical insulation must be supported in an appropriate manner; the self-supporting height of the insulation is determined by taking the mechanical resistance of FOAMGLAS® insulation into account, as well as the movement during contraction. For the purpose of dead load in a vertical support, the insulation will support its own weight on the face of the butt end of the insulation segment for a distance of 15 m (50 ft.). The thermal contraction requirements of the pipe metal with respect to the insulation system, however, would ultimately govern the number of supports and their location. Angle iron or metal plates must be welded onto the vessel or piping to support the insulation. The width of the support must be chosen so as to support the inner layer(s).To prevent a thermal break, the outer layer of insulation must be applied with the mid-point of the insulation section covering the insulation support ring.

6.6.2 Should the ring be wider, a supplementary layer may have to be installed at the insulation support location. Should there be varying thicknesses of insulation on a vessel, a support must be placed at the point where the different thicknesses meet.

6.6.3 Supports, cradles, skirts and legs welded directly onto the equipment must be insulated with the same thickness of insulating material as the equipment itself, in order to avoid thermal bridges. This insulation must extend over a distance equal to four times the insulation thickness and must never be less than 30 cm (12 in.). The cradle shall be designed to provide a sufficient bearing area to limit the compressive force on the insulation to 1.4 kg/cm^2 (20 psi) maximum at the load bearing area.

6.6.4 The insulation of the bottom heads, manholes and other individual items must also be fixed in place with stainless steel straps.

6.6.5 Hollow spaces between object and insulation must be filled with insulating materials to prevent "pumping" of enclosed air, in case of extreme temperature changes. Hollow spaces may be filled with approved loose fill insulation material.

7. Insulation Finish

7.1 Mastic and metal finish

7.1.1 Apply mastic according to manufacturer's recommendations over the completed insulation installation.

7.1.2 Metal jacketing shall be applied over the mastic coating with the joints positioned to shed water. Follow standard engineering specifications for jacket application.

7.2 Terostat coating

7.2.1 Terostat PC® FRi is a silicone polymer. It is factory applied on all outer layer FOAMGLAS® elements. For this purpose, Terostat PC® FRi shall be delivered in suitable containers and cartridges. Application includes the use of a bead of Terostat PC® FRi on top of all joints, by cartridge, trowel, or gun. The Terostat PC® FR bead is then smoothed flush with the factory applied Terostat PC® FR surface, so that the coverage will be at least as thick as the pre-applied coat, and that there will be a complete closure of the coating system. A flexible spatula (Teflon) covered with a soapy water solution may be used in order to achieve a smooth finish with no drag marks. Due to the elasticity of the Terostat, this coating is suited to be installed on systems requiring no expansion/contraction joints.

7.3 PITTWRAP® B100 jacketing and metal jacket finish

7.3.1 PITTWRAP® B100 jacketing wrap can be factory pre-applied to reduce the chance of wrinkles and holidays. When applied at site, wrap PITTWRAP® B100 jacketing over the insulation, avoiding wrinkles and holidays. Work with full width jacketing on straight piping, and Aluminum/butyl tape or cut-to-fit jacketing strips on the fittings. Sufficient pressure should be given at the overlapping seams, to create a firm bond between foils at the butyl material level. Follow manufacturer's recommendations for the application of jacketing. Observe application temperature limits for jacketing at all times during the field application of the aluminum/butyl jacketing.

7.3.2 Sealing on site is done by overlapping the PITTWRAP® B100 jacketing, recommended width to be 100mm (4 in.). Sufficient pressure will ensure sufficient bond between pre-applied foil and tape at butyl level. Use a wallpaper roller to help seal the overlap.

7.3.3 Apply metal jacketing per engineering standards or practice codes.

8. Inspection

8.1 The general contractor, insulation contractor and owner shall provide sufficient inspection during the insulation and finish application. Continuous inspection of the application is not to be considered a requirement of Pittsburgh Corning.

8.2 Inspect all insulation and accessory materials to be certain they are applied in conformance with the specification recommendations. Joints must be tight, sealing and flashing must be thorough and water-tight, and finishes must be uniform and free of defects.

9. Quality Assurance

9.1 The insulation manufacturer's quality system including its implementation, shall meet the requirements of ISO 9001:2008. The manufacturer will furnish evidence of compliance with the quality system requirements of ISO 9001:2008.

10. Certificates

10.1 The manufacturer will furnish evidence of compliance with the quality system requirements of ISO 9001:2008.

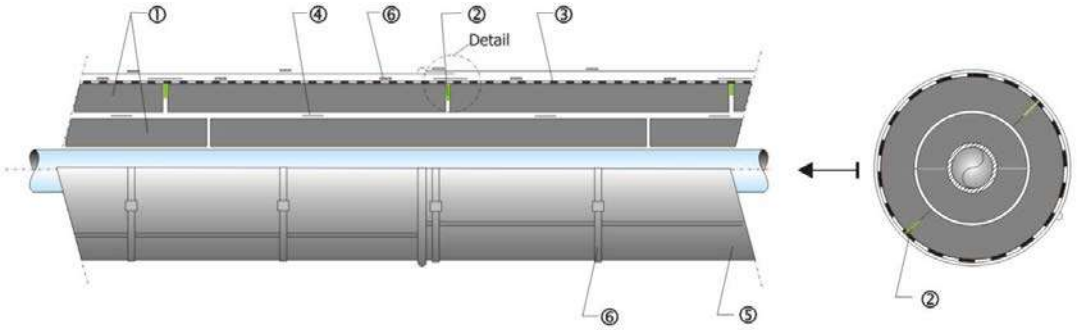
11. Product Data Sheets

11.1 Product data sheets for Pittsburgh Corning products may be accessed on line at: http://www.foamglas.com/. The following are Pittsburgh Corning products referenced in this specification:

11.1.1	FOAMGLAS® ONE™ Insulation	FI-003
11.1.2	Hydrocal® B-11	FI-169
11.1.3	PC® 150 glass reinforcing mesh	
11.1.4	PC® 80M Mortar	FI-289
11.1.5	PC® Fabric 79	FI-159
11.1.6	PC® High Temperature Anti-Abrasive	
11.1.7	PC® RTV 450 Silicone Adhesive	FI-244
11.1.8	PITTCOTE® 300 Finish	FI-120
11.1.9	PITTSEAL® 444N^{s} sealant	FI-164s
11.1.10	PITTSEAL® 444N sealant	FI-164
11.1.11	PITTSTOP™ 196 Vapor Stop	FI-320
11.1.12	PC® 42 Cryogenic Adhesive	FI-319
11.1.13	PITTWRAP® B100 jacketing	FI-281
11.1.14	Terostat PC® Fri	

12. Appendix A: Technical Drawings

12.1 Appendix A1: Pipe insulation



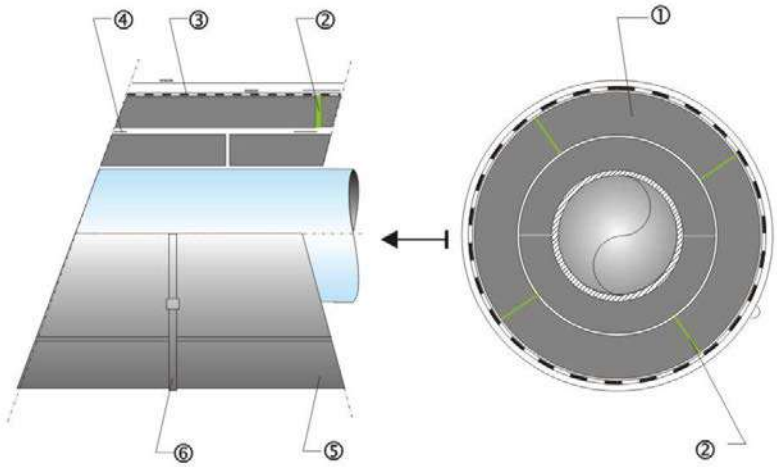
Detail: System A
Pre-Applied Alubutylfoil

Detail: System B
Site-Applied Alubutylfoil

Detail: System C
Terostat precoated

① Cellular Glass
② Sealer, Cryogenic Adhesive
③ Vapour Retarder
④ Tape
⑤ Metal Jacketing (when applicable)
⑥ Tension Strap

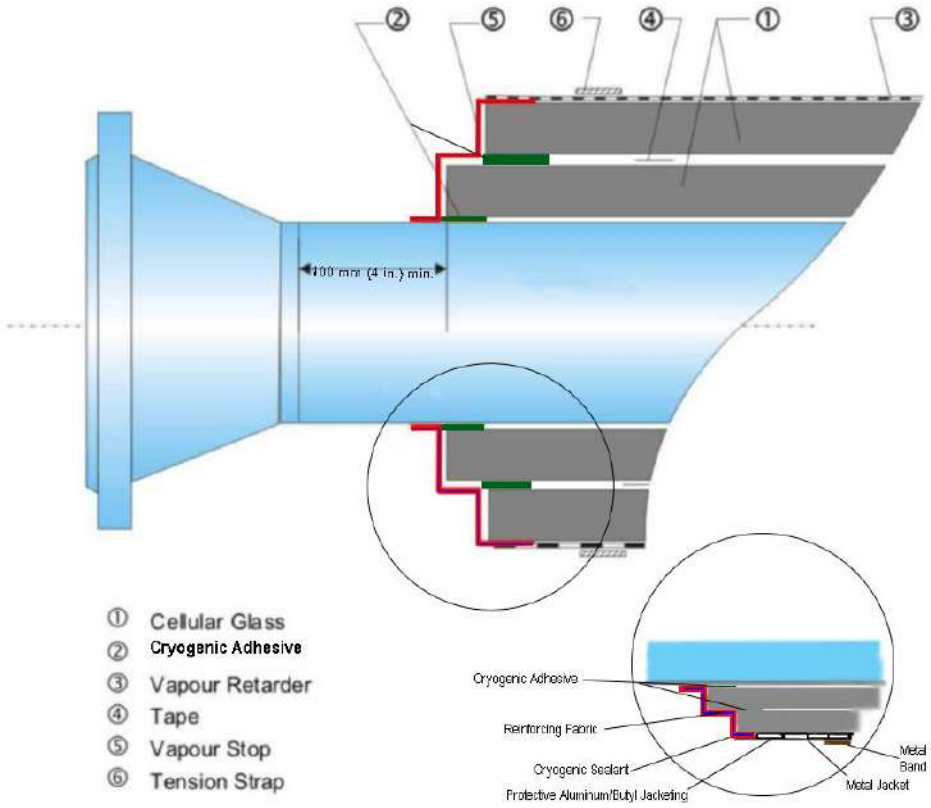
12.2 Appendix A2: Pipe Insulation: Quarter-Segments



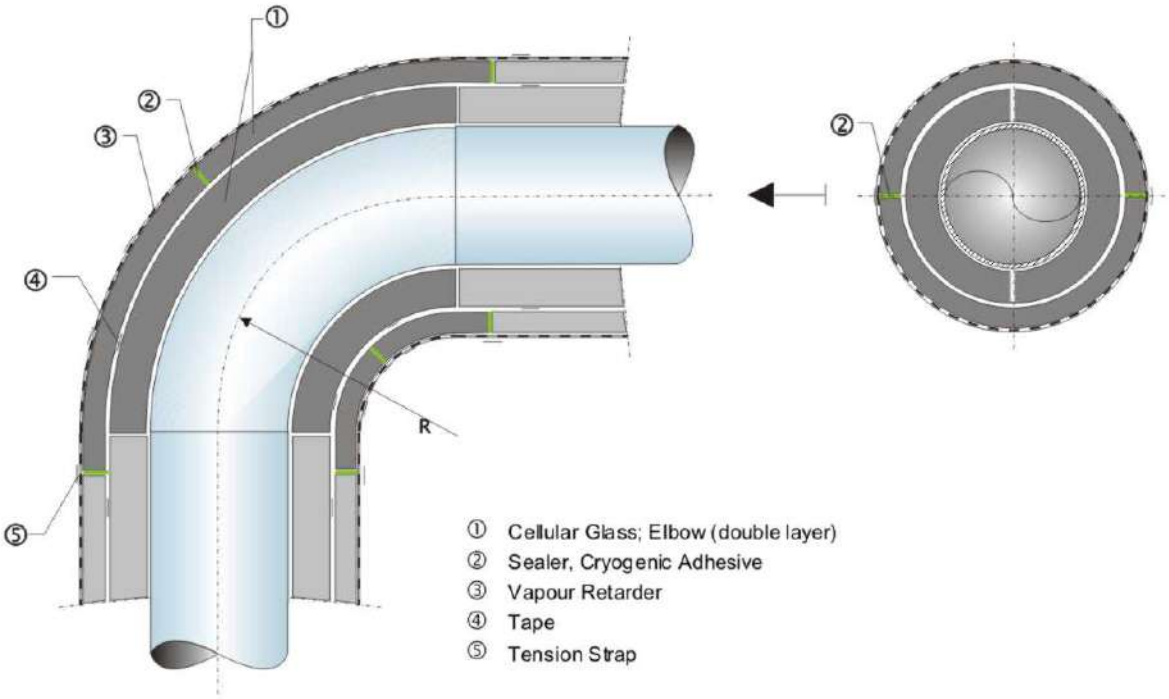
Staggered Joints

① Cellular Glass; Quarter Segments
② Sealer, Cryogenic Adhesive
③ Vapour Retarder
④ Tape
⑤ Metal Jacketing (when applicable)
⑥ Tension Strap

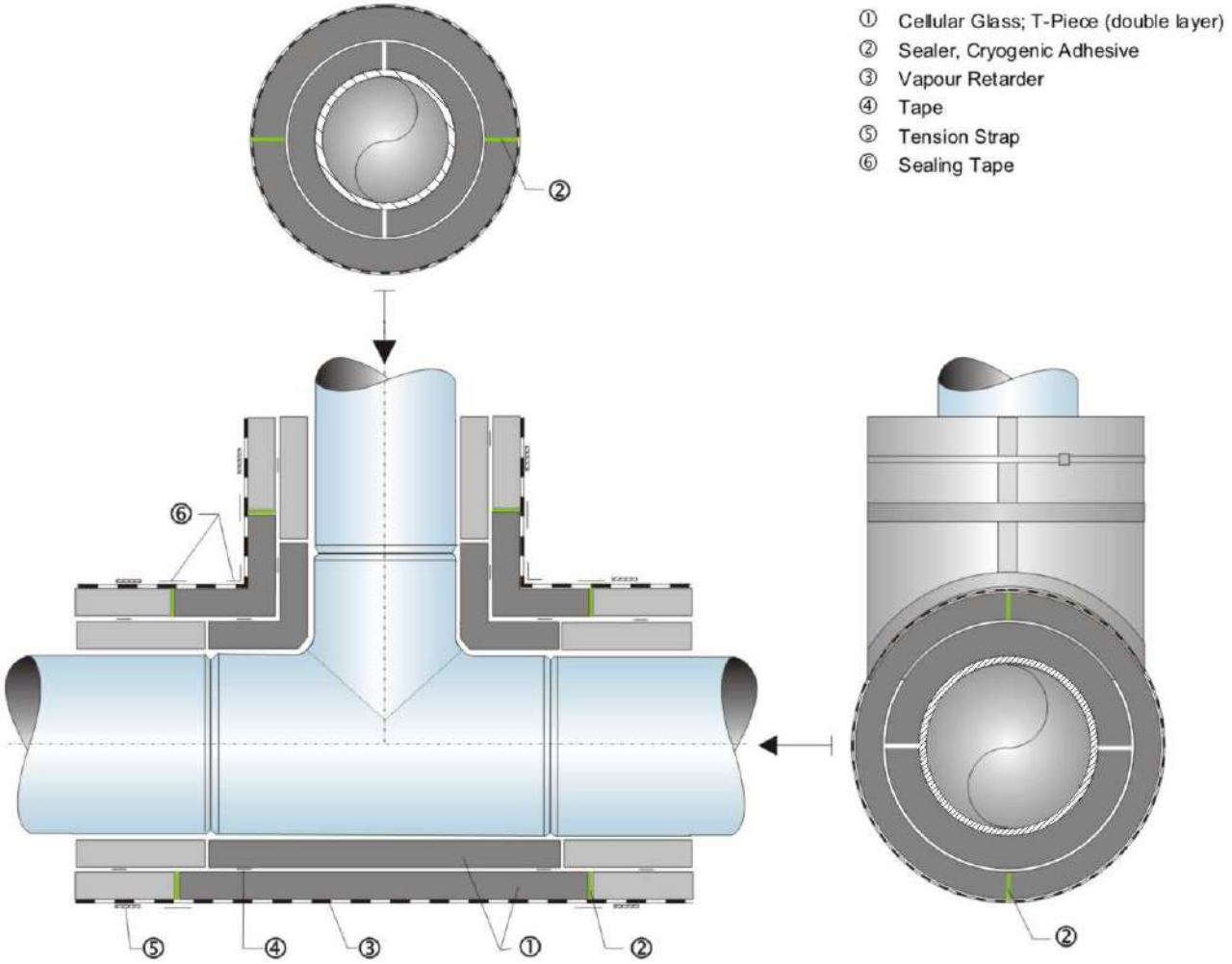
12.3 Appendix A3: Pipe Termination



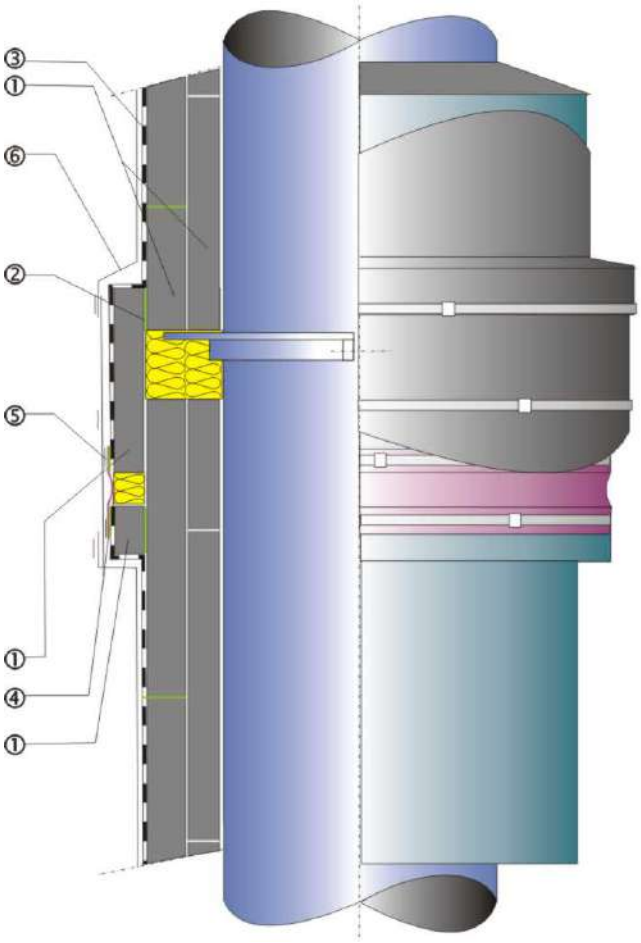
12.4 Appendix A4: Elbow Insulation



12.5 Appendix A5: Tee piece insulation

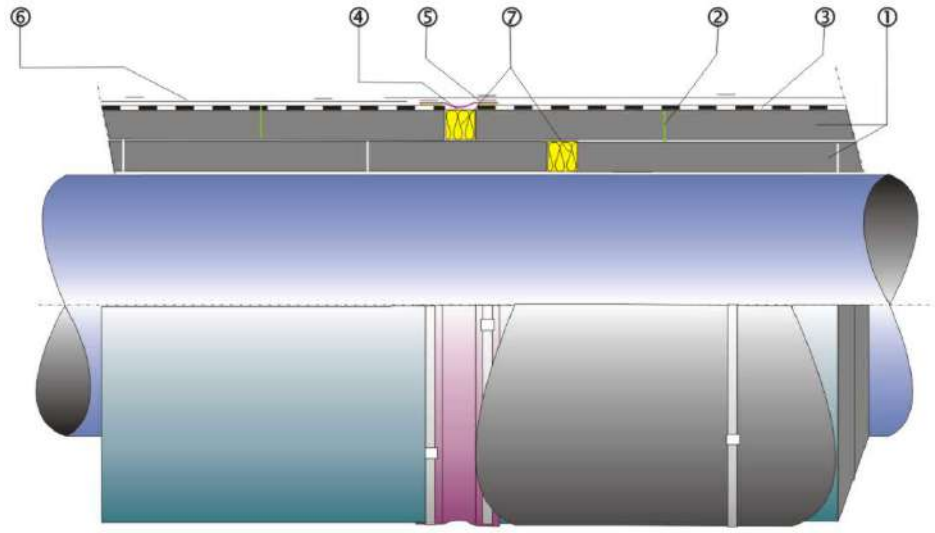


12.6 Appendix A6: Vertical Expansion / Contraction Joint



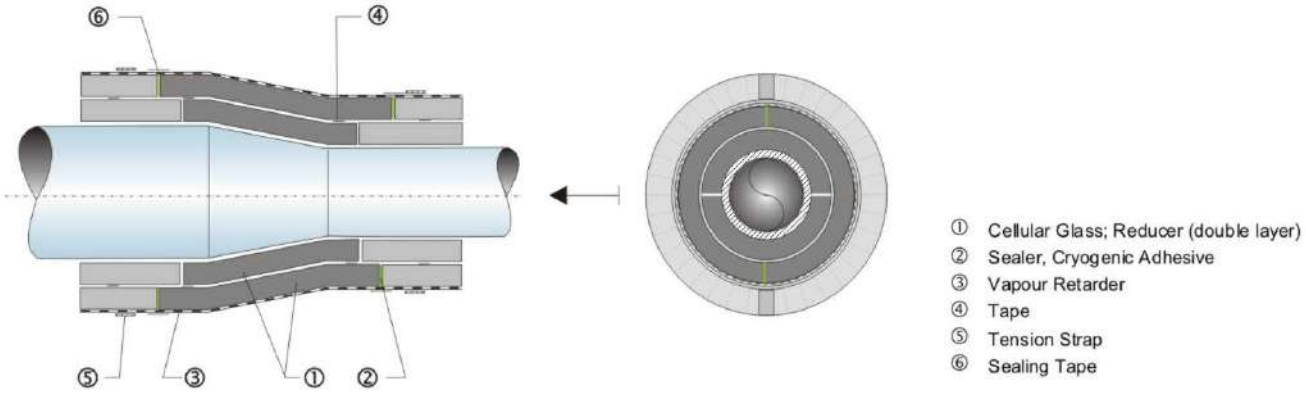
① Cellular Glass
② Sealer, Cryogenic Adhesive
③ Vapour Retarder
④ Rubber Vapour Barrier
⑤ Tension Strap
⑥ Metal Jacketing (when applicable)

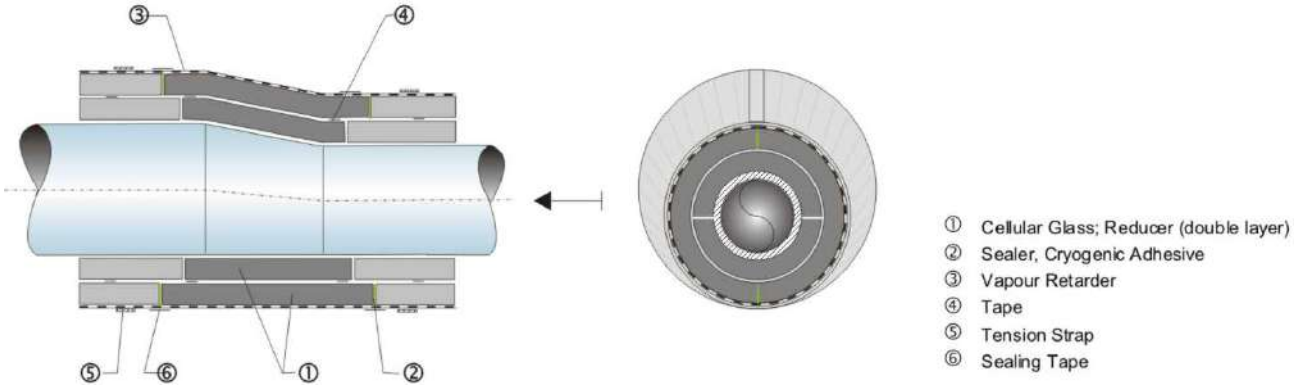
12.7 Appendix A7: Horizontal Expansion / Contraction Joint



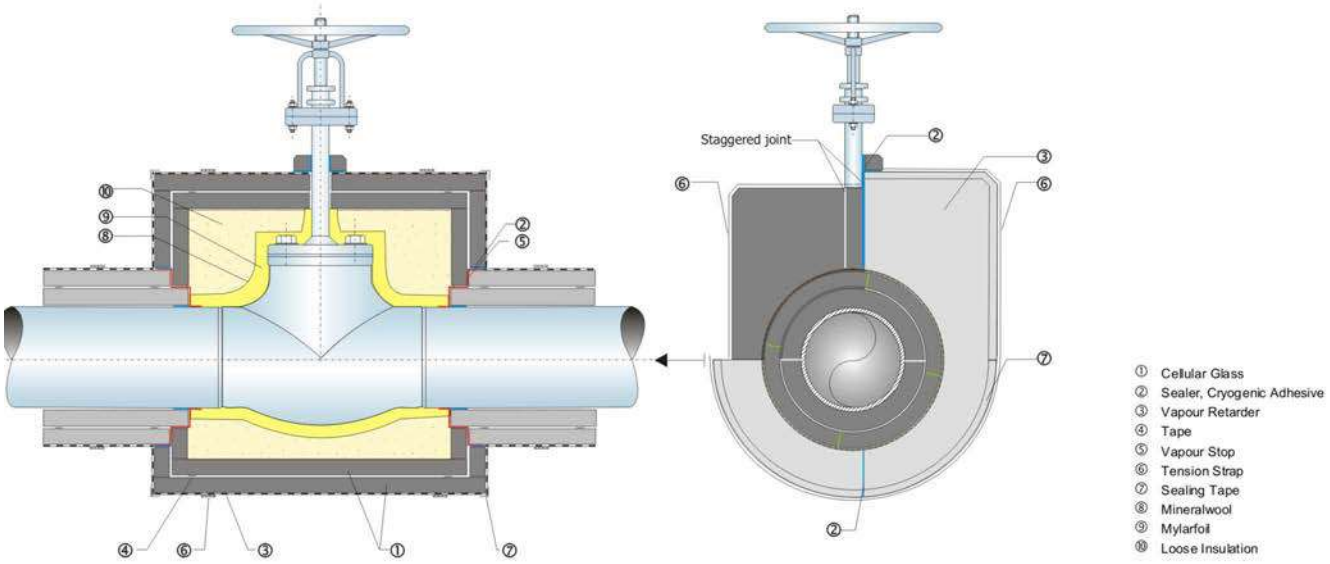
① Cellular Glass
② Sealer, Cryogenic Adhesive
③ Vapour Retarder
④ Rubber Vapour Barrier
⑤ Tension Strap
⑥ Metal Jacketing (when applicable)
⑦ Mineral Wool

12.8 Appendix A8: Cone Insulation

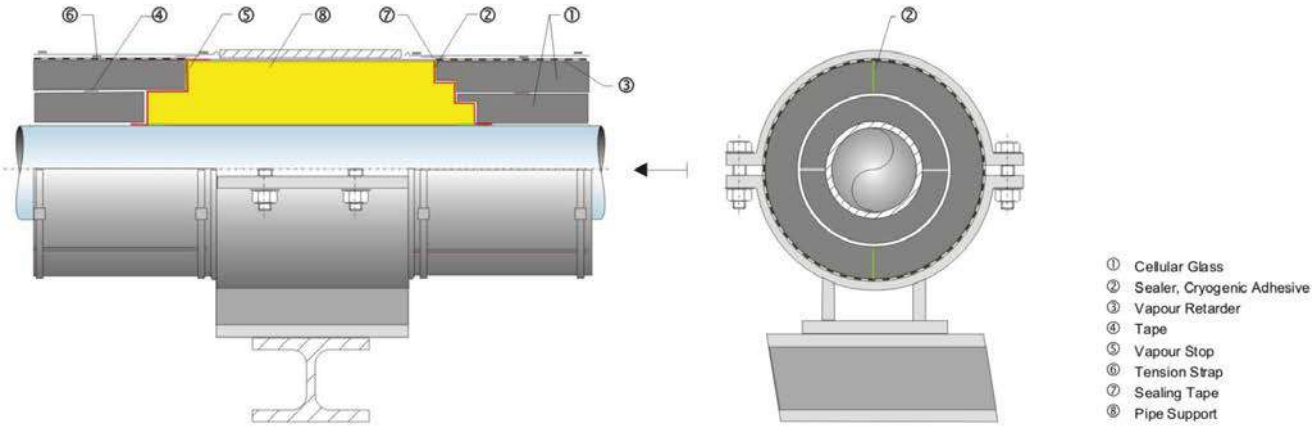




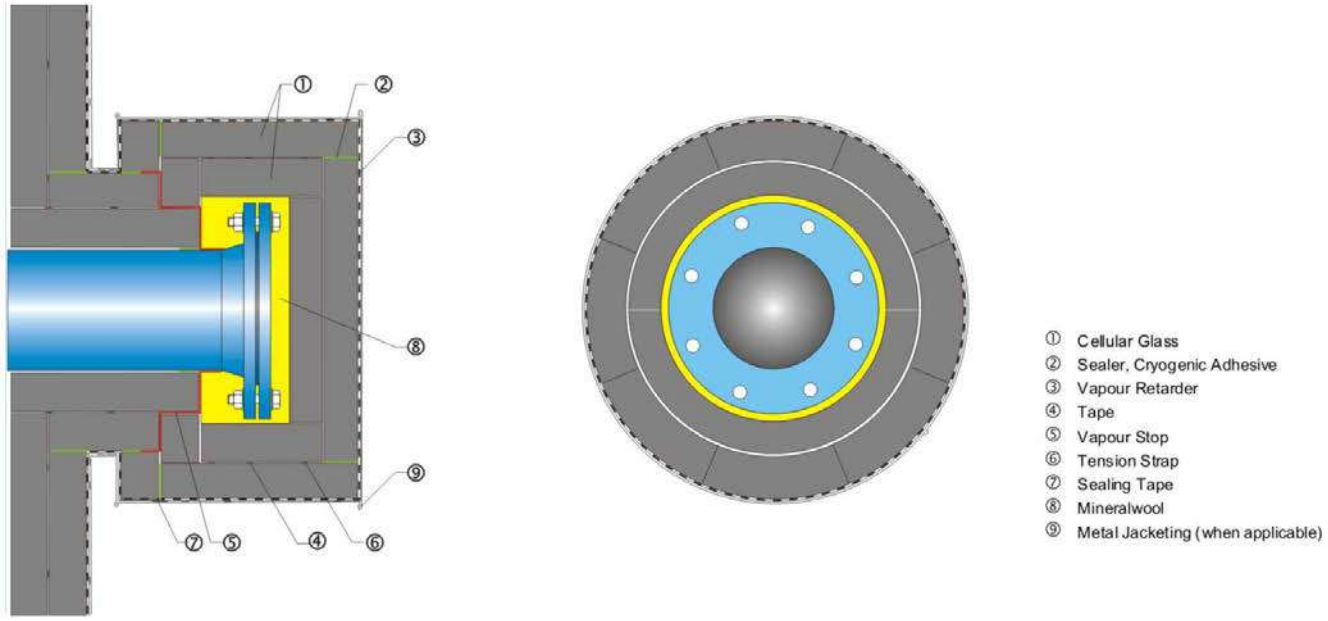
12.9 Appendix A9: Valve Insulation



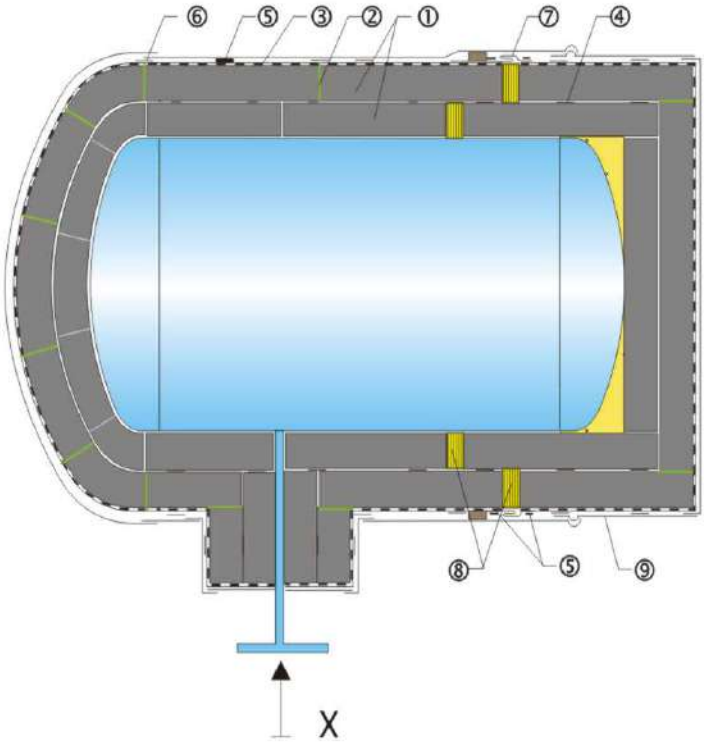
12.10 Appendix A10: Pipe Support Insulation

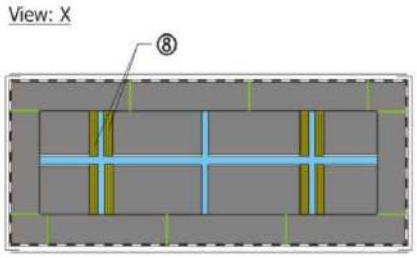


12.11 Appendix A12: Nozzle



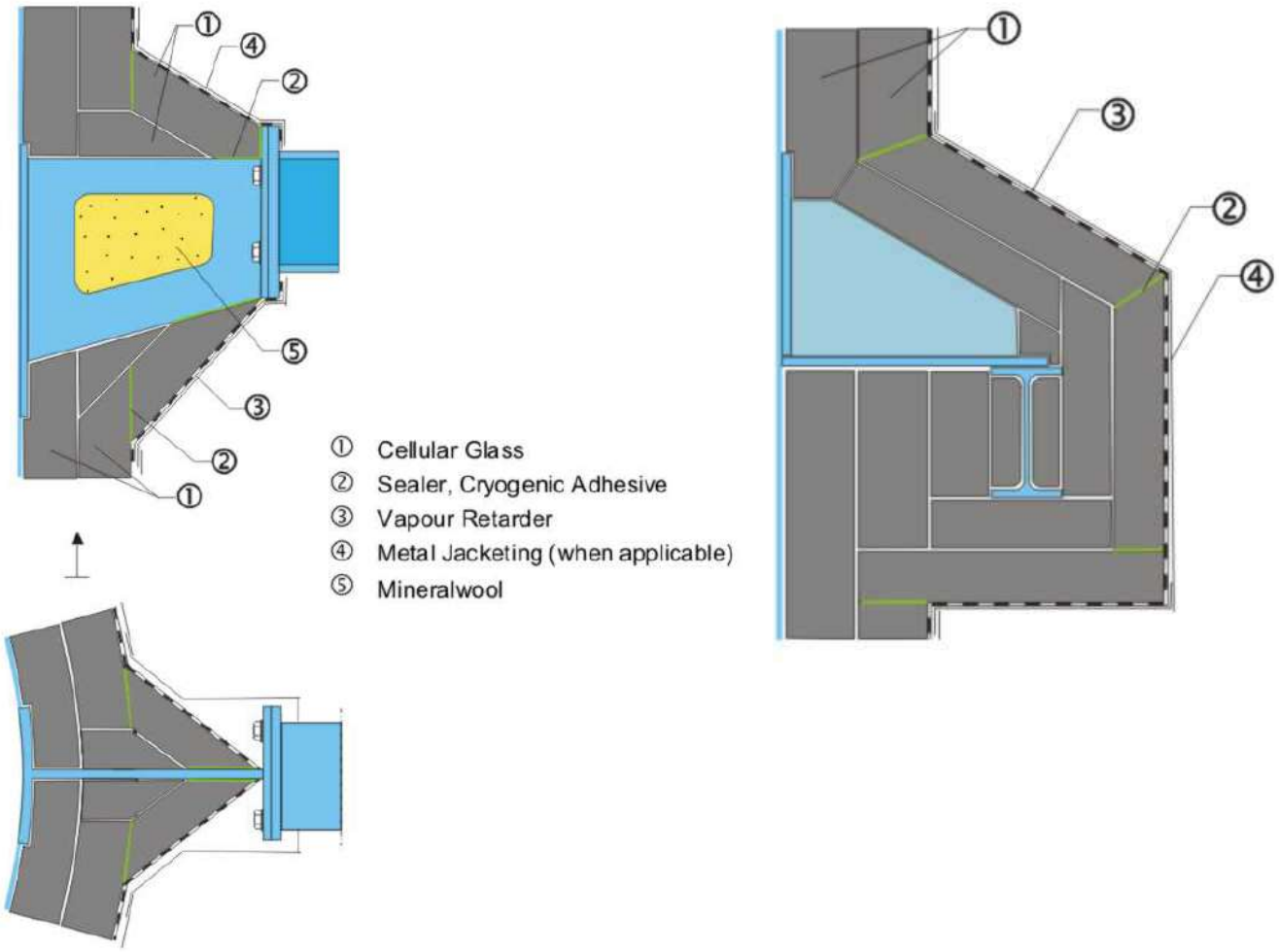
12.12 Appendix A13: Vessel



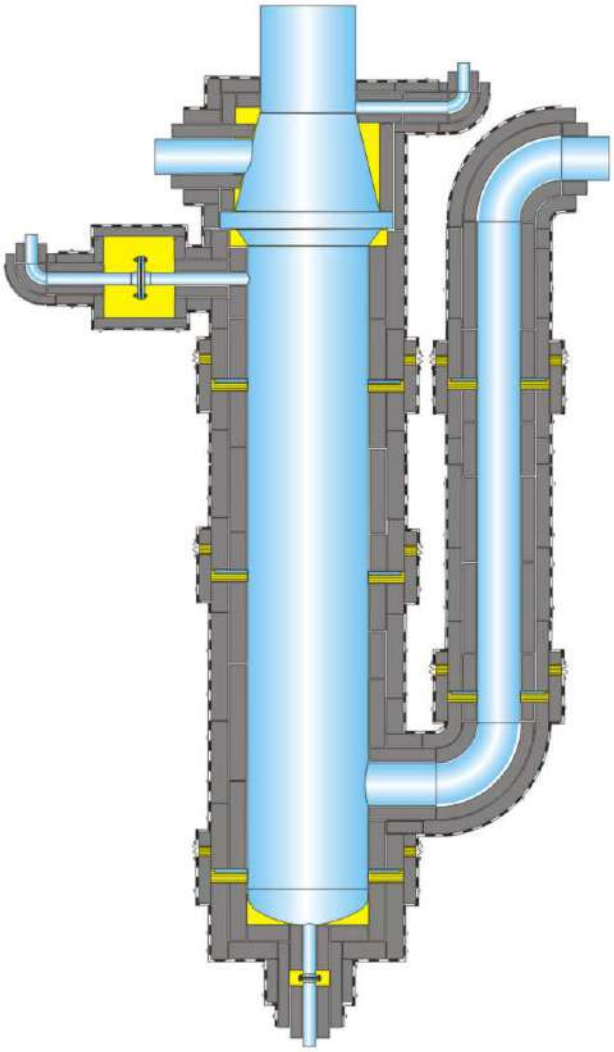


① Cellular Glass
② Sealer, Cryogenic Adhesive
③ Vapour Retarder
④ Tape
⑤ Tension Strap
⑥ Sealing Tape
⑦ Rubber Vapour Barrier
⑧ Mineralwool
⑨ Metal Jacketing (when applicable)

12.13 Appendix A14: Bracket



12.14 Appendix A15: LNG pump



13. Appendix B: Other Product Manufacturers

TEMP-MAT® as supplied by Alpha Associates 2 Amboy Avenue Woodbridge, NJ 07095 Telephone: (732)634-5700 Fax: (732)634-1430 http://www.alphainc.com/site/ or equal.

AAA Acme Rubber Company 2003 E. Fifth St., Bldg. #1 Tempe, AZ 85281
Telephone: (480)966-9311 Fax: (480)966-2273
http://www.acmerubber.com/neosheet.htm or approved equal.

3M Scotch No. 880 tape, or equivalent

14. Additional Information

Questions regarding this report should be directed to:

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