



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

FOR THE CARTAGENA REFINERY EXPANSION PROJECT

CB&I CONTRACT NO. 166000

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	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 2 of 53

Table of Contents

Contents	Page
1.0 SCOPE	3
2.0 SUBCONTRACTOR RESPONSIBILITY	3
3.0 REGULATIONS	3
3.1 Codes	3
3.2 Reference Specifications	4
4.0 DESIGN	4
4.1 Definitions	4
4.2 Specific Requirements	4
4.3 Extent of Insulation.....	5
5.0 ADDITIONAL REQUIREMENTS	8
5.1 Welding	8
6.0 PAINTING	8
7.0 MATERIAL	9
7.1 General.....	9
7.2 Insulation Material for Piping and Equipment	9
7.3 Weatherproofing	10
7.4 Accessories Materials	10
8.0 INSTALLATION	10
8.1 Application of Insulation.....	10
8.2 Application of Weatherproofing	14
9.0 INSPECTION	16
10.0 ATTACHMENTS	17
APPENDIX A.....	51
INSULATION REQUIREMENTS FOR MODULE WORK.....	51
1.0 GENERAL	51
2.0 MATERIALS	51
2.1 Expanded Perlite	51
2.2 Metal Jacketing	51
2.3 Sealing Membrane	51
2.4 Insulation design	52

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 3 of 53

1.0 **SCOPE**

- 1.1 This specification covers the minimum requirements for material, fabrication, installation and application of insulation on piping and equipment to be used for "Hot Service".
- 1.2 This specification excludes insulation for buildings, ventilation and air conditioning equipment, ducts, boilers, coke drums and furnaces. It does not include fireproofing or insulation for cold service. Modules shall be fabricated in CB&I facility, Island Park, in Beaumont, Texas.
- 1.3 Appendix A has been added to this specification for the Work to be done in island Park facility.

2.0 **SUBCONTRACTOR RESPONSIBILITY**

- 2.1 Any conflict between the requirements of this specification and related codes, standards, data sheets, drawings, requisition, etc., shall be referred to Contractor for clarification/resolution.
- 2.2 Subcontractor shall not make assumptions to replace information not furnished by Contractor. Subcontractor is required to obtain necessary information from Contractor or other reliable sources. Any and all claims arising from lack of knowledge of required information would be rejected by Contractor.
- 2.3 Subcontractor shall list and fully describe all deviations from this specification and the related codes.
- 2.4 Subcontractor shall field verify all (existing) dimensions and conditions shown on Contractor's drawings.
- 2.5 Subcontractor shall follow manufacturer's recommendation in safe handling of insulation, materials and use of required safety equipment.

3.0 **REGULATIONS**

The following documents, including applicable addenda, constitute a part of this specification as described herein. The referenced edition of these documents shall be that which is in effect as of the issue date of this specification.

3.1 **Codes**

Comply with all applicable federal, state and local codes including:

- ASTM American Society for Testing and Materials
- C168 Definitions of Terms Relating to Thermal Insulating Materials
- C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
- C195 Mineral Fiber Insulating Cement
- C335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation
- C449 Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- C450 Recommended Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging and Dished Head Segments.
- C547 Specification for Mineral Fiber Preformed Pipe Insulation
- C592 Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation
- C612 Specification for Mineral Fiber Block and Board Thermal Insulation

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 4 of 53

- C795 Specification for Wicking-Type Thermal Insulation for Use over Austenitic Stainless Steel
- C871 Chemical Analysis of Thermal Insulation material for Leachable Chloride, Fluoride, Silicate plus Sodium Ions
- C1335 Standard Test Method for Measuring Non-Fibrous Content of Man-Made Rock and Slag mineral Fiber Insulation

3.2 Reference Specifications

- 000-SP-MU10-0017 Coating Specification
- 000-SP-MU10-0024 Sound Control Insulation for Piping, Valves and Flanges

4.0 DESIGN

4.1 Definitions

- 4.1.1 The term "Hot Service" applies to operating temperatures at or above ambient.
- 4.1.2 The term "cylindrical surfaces" applies to equipment such as tanks, vessels, ducts, heat exchangers, etc. as well as to piping.
- 4.1.3 Unless otherwise specified, the term "Piping" applies to the whole pipe system, which includes pipes, fittings, valves, and other in-line piping specialties.
- 4.1.4 The term "Equipment" applies to vessels, tanks, heat exchangers, pumps, compressors, turbines, etc., including associated parts and appurtenances.
- 4.1.5 The abbreviation OD when used without a description applies to the outside diameter of the insulation and/or finish covering.
- 4.1.6 The term "low alloy steel" is steel containing up to five and one-half (5-1/2) percent chromium or three and one-half (3-1/2) percent nickel.
- 4.1.7 The term "weatherproofing" refers to water (rain water, etc.) tight finish. It does not mean vapor tight.
- 4.1.8 The other terms used in this specification shall be in accordance with ASTM Specification C168.
- 4.1.9 Whenever in this specification the word Contractor is used, it shall be understood as referring to CB&I, except in the event the contract is directly with the Owner. In that case, the word Contractor shall be deemed to mean a representative of the Owner.
- 4.1.10 Whenever in this specification, the word Subcontractor is used; it shall be understood as referring to the party supplying all material and/or labor, etc., as described in paragraph 1.1.

4.2 Specific Requirements

- 4.2.1 Modification or deviation from this specification in part or in total shall not be made without written approval of the Contractor's Insulation Engineer or Contractor's Representative.
- 4.2.2 Insulation materials are identified with trade names of acceptable manufacturers for the purpose of describing the quality of materials required. Other products may be acceptable provided they meet technical properties as tested by independent laboratory and only with Contractor's written approval.

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 5 of 53

- 4.2.2.1 All substitutions must be described in sufficient detail including reason for change, cost impact and data sheets shall accompany the substitution request.
- 4.2.2.2 Material offered as a substitute may be used only if approved by Contractor. Contractor shall be the sole judge of the quality and suitability of the proposed material.
- 4.2.3 Insulation (as well as finish) shall not be applied to any piping, vessel or other equipment until it has been inspected, tested, approved and released for the application of insulation by the Contractor.
 - 4.2.3.1 In cases where it is necessary to insulate before completing this work, prior written approval from the Contractor must be obtained.
- 4.2.4 Aluminum shall not be used over insulation on any equipment or piping whose maximum, normal or short term operating temperature exceeds 1100°F (593°C). Aluminum shall not be used over insulation if insulation is being used to justify small relief valve in event of fire.
- 4.2.5 Aluminum shall not be used over Stainless Steel piping and equipment in hot service. Stainless steel jacketing without moisture barrier shall be used above 1100°F (593°C) temperature.
- 4.2.6 Galvanized or zinc coated materials shall not be in contact with metal surfaces that have temperatures above 700°F (371°C). It shall not be used over stainless steel piping and equipment.
- 4.2.7 Insulation material shall comply with chloride limit per ASTM C795. ASTM C795 puts the results of ASTM C871 in graphical list to illustrate a range of acceptable chloride concentrations in conjunction with silicate concentrations.
- 4.2.8 Insulation materials containing asbestos shall not be used.
- 4.2.9 No insulation material shall be applied between pipe and tracer except for spacers (by others) to prevent local overheating of the pipe.
- 4.2.10 Contact between dissimilar materials, which might cause galvanic corrosion, shall be avoided.
- 4.2.11 All materials shall be protected from rain, etc. while in storage and during application. The damaged material shall be replaced by insulation Subcontractor at no cost to Contractor.
- 4.2.12 All insulation and finish shall be applied using the best modern practice and finished work shall display a neat appearance.
- 4.2.13 All finished insulation and weatherproofing work shall be installed weather tight and shall remain weather tight during operation.
- 4.2.14 Insulation material (as delivered) shall not contain crystalline silica.

4.3 Extent of Insulation

- 4.3.1 General
 - 4.3.1.1 The Equipment List and the Piping Line List lists the normal operating temperature, required thickness of insulation and insulation requirement codes for equipment and lines which are to be insulated in accordance with this specification.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 6 of 53

- 4.3.1.2 The thicknesses given on the schedules are those required for the size of the line/equipment shown.
- 4.3.1.3 Thicknesses presented on the schedules do not include finish thicknesses.
- 4.3.1.4 P&IDs, piping drawings, isometrics and equipment drawings indicate the extent of insulation.
- 4.3.1.5 Skid mounted piping and equipment shall be insulated per this specification and unless otherwise specified, in applicable purchase documents, by the insulation subcontractor.
- 4.3.1.6 Insulation and weatherproofing materials for valves, flanges, fittings, etc. shall be same as the materials of the adjacent pipes and equipment.
- 4.3.1.7 Equipment below 30 in. (760 mm) O.D. shall be insulated and weatherproofed same as piping.

4.3.2 Insulation Requirement Code

- 4.3.2.1 The insulation requirement code which indicate types of insulation is as follows:

Code Legend

Description

(N)	Insulation Not Required
(H)	Heat Conservation Insulation
(P)	Personnel Protection Insulation
(S)	Steam Tracing Insulation
(E)	Electric Tracing Insulation
(R)	Controtrace
(A)	Acoustic Insulation

4.3.2.2 Insulation Not Required (N)

(N) Insulation shall not be applied if there is no need to prevent heat loss, protect personnel, and improve thermal gradient or sound control.

4.3.2.3 Heat Conservation Insulation (H)

(H) Insulation shall be applied to conserve heat in piping and equipment operating above 150° F (66°C). See Paragraph 4.3.3.1 for limitations.

4.3.2.4 Personnel Protection Insulation (P)

(P) Insulation shall be applied to surfaces, which satisfy the following conditions:

- Temperature of the surface shall be above 150° F (66°C).
- The surface must be confined within normal working areas and be located where personnel could inadvertently contact the surface.

(P) Insulation shall extend as follows:

- To a height of 7 ft. (2.1 m) above the floor or platform level.
- Within 2 ft. (600 mm) from the platform edges.
- When the uninsulated portion of piping or equipment requiring (P) insulation is less than 10 ft. (3 m) then such portion shall also be insulated.

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 7 of 53

- Where personnel protection (P) insulation is required, protection shall be provided by expanded metal guards. Installation and design of personnel guard shall be the responsibility of insulation subcontractor.

4.3.2.5 Steam (S); Electric (E) Tracing; and Controtrace (R) Insulation

(S); (E); or (R) Insulation shall be applied to traced piping and equipment to prevent freezing, maintain operating temperature or for viscosity control. Steam (S); Electric (E); and Controtrace (R) traced systems shall be completely insulated with cellular glass including valves, flanges and other fittings.

4.3.2.6 Acoustic Insulation (A)

(A) Insulation shall be applied to piping and equipment for the control of radiated noise. The materials and application shall be per Engineering Specification, 000-SP-MU10-0024 "Sound Control Insulation for Piping Valves and Piping".

4.3.3 Limitations

4.3.3.1 The following shall not be insulated for (H) Heat Conservation Insulation unless otherwise specified:

- Flanged Valves (including safety valves) and Flanges except as noted in Para 4.3.3.5
- Pipe supports and guides
- Manholes, handholes and nozzles where temperatures are less than 260°C (500°F)
- Bottom heads of skirt supported equipment, 760 mm (30 in.) and less in diameter
- Inside of skirts on skirt supported towers and vessels, 760 mm (30 in.) and less in diameter
- Channel covers operating below 93°C (200°F)
- Shell and tube heat exchanger flanges
- Steam traps and the outlet side of steam trap piping
- Steam condensate lines
- Untraced branches from traced lines downstream of the first block valve
- Drain and vent piping on insulated equipment downstream of the first block valve
- Nameplates which indicate design and/or operating data

4.3.3.2 Pump cases, coolers and condensers shall normally not receive (P) personnel protection insulation.

4.3.3.3 Expanded metal guards or other protective devices shall be Installed where personnel protection is necessary.

4.3.3.4 Steam condensate lines downstream of the steam trap, valves and flanges in heat conservation (H) are not insulated but if they are within (P) limits (Paragraph 4.3.2.5) they shall be insulated.

  Refinería de Cartagena S.A.	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 8 of 53

- 4.3.3.5 Preformed or molded type insulation must be used on steam (S); electric (E); and controtrace (R) Traced Equipment and Piping.
- 4.3.3.6 Where tracing is indicated, pipe insulation must have sufficient oversize to cover both tracing and pipe.
- 4.3.3.7 All components or piping receiving tracing shall be fully insulated.
- 4.3.3.8 Pumps operating above 400°F (204°C) shall be insulated. They can be insulated at lower temperatures if required for process reasons or if they are traced.
- 4.3.3.9 Unless otherwise noted, extent of equipment insulation will be considered that portion up to, but not including, the first flange of a given nozzle connection.
- 4.3.3.10 Insulation on uninsulated branch of an insulated line shall be extended four times the insulation thickness.
- 4.3.3.11 Refractory lined vessels shall not be externally insulated.
- 4.3.4 Insulation Thickness
 - 4.3.4.1 The insulation thickness for personnel protection (P) based on size of pipes and equipment and operating temperatures, is tabulated in Attachment II.
 - 4.3.4.2 The insulation thicknesses for other insulation services (H, S, E and R), based on size of equipment and pipes and operating temperatures, are tabulated in Attachment III.
 - 4.3.4.3 Thickness of each layer in multilayer insulation application shall conform to Attachment IV.
 - 4.3.4.4 Insulation thicknesses for all services shall be based on normal operating temperatures.

5.0 ADDITIONAL REQUIREMENTS

5.1 Welding

- 5.1.1 Field welding, such as welding of studs or nuts for insulation, on any piece of equipment or pipeline is prohibited without written approval of Contractor.
- 5.1.2 Welding of supports, pins, clips, studs, etc. for insulation securement to any equipment or vessels which are heat treated shall be completed at fabricator's shop or in the field (if field fabricated) prior to post weld heat treatment.
- 5.1.3 No field welding will be permitted on lined vessels, lined piping, coated vessel or any piping or equipment, which has been pressure tested.

6.0 PAINTING

- 6.1 Before application of insulation, all surfaces shall be cleaned to remove loose rust and paint, dirt, grease or other foreign matter. This shall be accomplished by solvent cleaning or water washing per SSPC-SP1 (Refer to Engineering Specification 000-SP-MU10-0017, "Coating Specification".)
- 6.2 Stainless steel items shall be brushed with stainless steel brushes only.
- 6.3 Any painting done prior to insulation shall be done in strict accordance with Project Painting Specification 000-SP-MU10-0017, "Coating Specification".

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 9 of 53

- 6.4 Insulation shall not be installed over field welds and other surfaces, which have not been leak tested and painted.

7.0 MATERIAL

7.1 General

- 7.1.1 Materials such as insulation blocks, preformed pipe covering, weatherproofing compounds, jackets, bands, etc. shall be new. Used or reject materials will not be accepted.
- 7.1.2 Materials shall only be applied within their temperature limitations.
- 7.1.3 All piping insulation shall conform to ASTM C585 pipe dimensions and tolerances.
- 7.1.4 At Contractor's option, material shall be subject to testing and inspection at the manufacturing plant prior to shipment to ensure compliance with ASTM designated properties.
- 7.1.5 All cellular glass in hot service shall be fabricated with Hydro Cal B adhesive. Asphalt adhesive is not acceptable.

7.2 Insulation Material for Piping and Equipment

- 7.2.1 The insulation material for (H and P) services shall be mineral fiber (wool) as defined in Attachment I. The insulation material for (S, E and R) service shall be cellular glass as defined in Attachment I. The insulation material for module fabrication shop work at Island Park facility in Beaumont, Texas shall be expanded perlite as defined in Attachment I and Appendix A.
- 7.2.2 Molded mineral wool pipe covering shall be used on pipe diameter 760 mm (30 in.) and less.
- 7.2.3 For pipe diameter above 760 mm (30 in.) and all equipment, insulation material shall be wire mesh blanket. The wire mesh shall be on the outside face (cold face) of the insulation. The stainless steel wire mesh shall be used on stainless steel piping and equipment.
- 7.2.4 On top heads of the vertical vessels, high density mineral wool block insulation (Appendix 1) shall be used.
- 7.2.5 Cellular Glass Insulation
- 7.2.5.1 Pipe diameter 16 in. (400 mm) and less, insulation shall be sectional (two-piece) pipe covering.
- 7.2.5.2 For pipe diameter above 16 in. (400 mm) and for all equipment, insulation shall be curved segments. Width of curved segments shall not be less than 6 in. (150 mm).
- 7.2.5.3 Curved segments shall fabricate to fit the contours of surface with minimum number of the through joints.
- 7.2.5.4 Cellular glass shall be fabricated per the Annex of ASTM C-552.
- 7.2.6 V grooved blocks, score blocks and scored bevelled blocks are not acceptable.
- 7.2.7 All fabrication shall be in accordance with ASTM C-450.
- 7.2.8 Preformed or prefabricated rigid pipe insulation shall be furnished in standard lengths with ends cut square. Inside diameters shall fit firmly on the specified pipe sizes and outside diameters shall correspond to a nominal pipe size (NPS).

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 10 of 53

7.3 Weatherproofing

7.3.1 Based on the maximum operating temperature indicated in the Equipment Insulation, Painting and Fireproofing List or Piping Line Schedule, jacketing material shall be as follows:

7.3.1.1 Aluminum jacketing up to 1100°F (593°C) (see Paragraph 4.2.4 for restrictions).

7.3.1.2 Stainless steel jacketing above 1100°F (593°C).

7.3.1.3 Stainless steel jacketing for all stainless steel pipes and equipment.

7.3.1.4 For all insulation codes, aluminum jacketing shall be plain finish.

7.3.2 Jacketing material qualifications are specified in the Attachment VIII.

7.3.3 Mastic for bottom heads shall be per Attachment VII.

7.4 Accessories Materials

All accessories materials shall be per attachments.

8.0 INSTALLATION

8.1 Application of Insulation

8.1.1 General

8.1.1.1 Insulation shall not be installed over wet surfaces.

8.1.1.2 Insulation shall be protected from moisture and rain at all times. Installed insulation shall dry prior to application of weatherproofing jacketing or mastic. Wet insulation shall not be applied. If insulation becomes wet, it shall be removed and discarded.

8.1.1.3 Insulation sections shall be trimmed as required to achieve tight fit without voids.

8.1.1.4 Fabricated or preformed insulation shall fit curvature of the surface to be insulated.

8.1.1.5 When pulled with securement (bands or wire as required by this specification) insulation shall fit snugly over the surface without leaving open joints.

8.1.1.6 All openings in the jacket for nozzles, brackets, etc. shall be cut as close as possible to achieve a tight fit.

8.1.1.7 All joints of multi layer construction, either preformed sections or block shall be staggered.

8.1.1.8 Bands used to secure insulation shall be installed straight and tension tight but shall not crush insulation.

8.1.1.9 Fill all voids and breaks as installation progresses with insulation cement.

8.1.2 Insulation for Piping System

8.1.2.1 Sectional insulation shall be sized to eliminate gaps and voids between surfaces and the insulation.

8.1.2.2 For single layer application, preformed pipe insulation shall be applied so longitudinal joints are staggered.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 11 of 53

- 8.1.2.3 Pipe insulation shall be applied in multiple layers when required. All joints in the outer layer shall be staggered with the inner layers to minimize the number of through joints.
- 8.1.2.4 Each layer shall be secured per this specification before proceeding with the next layer or weatherproofing jacketing.
- 8.1.2.5 Mineral wool insulation through 12 in. (300 mm) insulation O.D. shall be secured with #16 AWG (1.3 mm) diameter stainless steel wire spaced 3 per section, each layer.
- 8.1.2.6 Mineral wool insulation over 12 in. (300 mm) O.D. to 24 in. (610 mm) O.D. shall be secured with 1/2 in. (13 mm) wide stainless steel bands at the rate of two per section.
- 8.1.2.7 Cellular glass insulation through 24 in. (610 mm) O.D. shall be secured with 1/2 in. (13 mm) wide bands spaced at two per section of pipe Insulation, each layer.
- 8.1.2.8 Insulation for pipe sizes over 24 in. (610 mm) O.D. shall be secured with 3/4 in. (19 mm) wide stainless steel bands spaced on 12 in. (300 mm) maximum centers for each layer.
- 8.1.2.9 Wire ends and/or banding seals shall be pressed into the insulation to avoid projections.
- 8.1.2.10 On long vertical piping runs, the insulation Subcontractor shall furnish and install all clamped insulation supports (Attachment X). These supports shall be 1/2 in. (13 mm) less than insulation thickness and spaced at a maximum of 18 ft.-1 in. (5.5 m), (18 ft [5.4 m] for insulation and 1 in. [25 mm] for expansion joint). Support material shall be same as the piping material and shall be primed coated as required per project painting specification.
- 8.1.2.11 Expansion joints spacing for horizontal and vertical piping shall be per Attachment XI.
- 8.1.2.12 Insulation expansion joints for vertical piping shall be provided of each insulation support rings as a minimum.
- 8.1.2.13 The expansion joint shall be tightly packed with fiber glass loose fill insulation. (Attachment V, A-1).
- 8.1.2.14 Application details for insulation expansion joints for horizontal piping are shown in Attachment XI.
- 8.1.2.15 When fitting, flange and valve requires insulation, the material and thickness of insulation shall be same as the adjoining pipe insulation (except for removable insulation covers for special conditions).
- 8.1.2.16 Flange and valve insulation shall be shop or field fabricated from pipe Insulation per Attachment XII and ASTM C450.
- 8.1.2.17 Premolded and/or prefabricated elbows shall be used for all commercially available sizes.
- 8.1.2.18 Premolded and prefabricated fittings shall conform to dimensional requirements of ASTM C-585 and ASTM C-450.
- 8.1.2.19 On 2 in. (50 mm) and smaller pipefitting either routed or premolded fitting shall be used. If premolded fittings are not available, the fittings may be



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 12 of 53

insulated with finishing cement keeping same thickness as adjoining insulation (Attachment V, Material Code A-2).

- 8.1.2.20 The securement for fittings shall be same as adjacent piping.
- 8.1.2.21 Insulation adjoining uninsulated pipe, flanges and valves shall be bevelled down and terminated at a suitable distance from the flange to allow easy removal of nuts and stud bolts without damage to the insulation (recommended distance is length of flange bolts plus 1 in. [25 mm]).
- 8.1.2.22 All insulation termination shall receive a metal flashing collar. The metal flashing collar shall be made from same materials as the adjacent pipe jacketing.
- 8.1.2.23 Normally insulated pipes will have pipe supports. If insulated pipe rests directly on steel or concrete supports, insulation shall be cut back a minimum of 3 in. (75 mm) from both ends of the support to allow for longitudinal expansion.
- 8.1.2.24 All exposed insulation shall be weatherproofed with mastic or metal.
- 8.1.2.25 For piping with heat tracing, no insulation shall be applied between the pipe and the tracer, except the spacers if required, to prevent local over heating (hot spots) of the pipe may be used. These spaces will be installed by tracing Subcontractor.
- 8.1.3 Insulation for Equipment
 - 8.1.3.1 Equipment insulation supports, when required, shall be installed by the equipment fabricator in accordance with the Engineering Pressure Vessel Specification.
 - 8.1.3.2 Attachments on equipment beyond the insulation line, such as stiffening rings (Attachment XVIII), shall be considered as an integral part of the equipment and shall be insulated and finished in the same manner as the equipment. Thickness of insulation on such attachments and projections shall be the same as the adjoining insulation.
 - 8.1.3.3 Insulation on both the inside and the outside of skirts shall be equal to the shell insulation thickness. For equipment operating below 750°F (400°C), insulation of skirts shall extend at least a minimum of four times the vessel's insulation thickness. On equipment operating above 750°F (400°C), the insulation of skirts shall extend a minimum of 2 ft. (0.6 m) below skirt and vessel intersection.
 - 8.1.3.4 For operating temperatures 400°F (204°C) and higher, expansion springs shall be installed on all bands that secure the outer layer of insulation on cylindrical surfaces greater than 48 in. (1220 mm) O.D.
 - 8.1.3.5 When metal band exceeds 25 ft. (7.6 m) between securement points, one breather (expansion) spring should be used for every 2.5 ft. (7.6 m) of band length.
 - 8.1.3.6 For cylindrical equipment with diameters over 30 in. (760 mm), the wire mesh blankets shall be used.
 - 8.1.3.7 The top edge of wire mesh shall be tied to the insulation support rings with wires on 12 in. (300 mm) maximum centers to prevent sagging of wire mesh blanket.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 13 of 53

- 8.1.3.8 All seams of wire mesh shall be tied together with wire on 6 in. (150 mm) maximum centers.
- 8.1.3.9 Insulation shall be further secured with 3/4 in. (19 mm) wide bands on 12 in. (300 mm) maximum centers.
- 8.1.3.10 Expansion joints for vertical equipment shall be provided at each insulation support ring. The expansion space below the underside of the ring and the insulation shall be packed full with fiber glass loose fill insulation (Attachment V, Material Code A-1).
- 8.1.3.11 The fiber glass insulation for expansion joint shall be compressed to one third of the original thickness. For example, 3 in. (75 mm) of uncompacted fiber glass shall be compressed to 1 in. (25 mm).
- 8.1.3.12 For top head of vertical equipment, 10 lb/ft³ (160 kg/m³) density mineral wool blocks shall be used.
- 8.1.3.13 Insulation blocks for vessel heads shall be cut to fit the contour of vessel head. All blocks shall be fitted tightly to eliminate gaps and voids.
- 8.1.3.14 For top head of vertical equipment and both ends of horizontal equipment, the insulation shall be secured by a floating ring (Attachment VI, Material Code B-1) positioned in the center of the head and over the insulation. The floating ring shall not contact nozzles or any other protruding metal. Hold down bands 3/4 in. (19 mm) wide shall be installed and shall be spaced on 9 in. (225 mm) centers measured around the equipment's circumference. One end of a band shall be fastened to the floating ring and the other end shall be anchored to a band(s) or ring welded around the cylindrical section of the equipment close to the head.
- 8.1.3.15 Over the insulation, all equipment heads shall receive a layer of 1 in. (25 mm) hex mesh 20 gauge wire (Attachment VII, Material Code C-2) and 1/2 in. (13 mm) thick (dry) layer of finishing cement (Attachment V, A-2) trowelled to a smooth finish.
- 8.1.4 Insulation for Machinery
 - 8.1.4.1 Rotating machinery such as pumps, etc. shall be insulated with an insulated metal box. The box shall be of the removable type, which can be removed or installed without damaging insulation.
 - 8.1.4.2 Insulation shall be attached inside of the metal box with wire mesh facing and shall maintain schedule thickness.
 - 8.1.4.3 Flexible blanket type removable insulation covers may be used with the Contractor's written approval.
- 8.1.5 Attachments
 - 8.1.5.1 Code inspection plates, stampings, nameplates, data plates, manhole, handhole, etc. on equipment shall be left visible by cutting back insulation and properly sealing openings against moisture penetration with high temperature flashing compound.
 - 8.1.5.2 The insulation details for removable manhole and handhole covers are shown in Attachment XXII.
 - 8.1.5.3 Removable blankets over stainless steel lines or equipment may be used with the Contractor's written approval.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 14 of 53

8.1.5.4 If vertical lines are steam or electric traced, insulation supports shall provide clearance provision for the tracer.

8.1.5.5 Insulation Subcontractor shall be responsible for installing bolt-on or clamped type insulation supports where required to prevent insulation from sliding.

8.1.6 Instruments

8.1.6.1 Insulation for instrument shall be applied in a way so that there is no interference with either the operation or function of instrument and allow all gages, etc. to remain unobstructed.

8.1.6.2 Insulation details for level controllers are shown in Attachment XIX.

8.1.7 Expansion Joints

Insulation details for pipe expansion joints are shown in Attachment XX.

8.1.8 Steam Turbine

8.1.8.1 Steam turbine shall be insulated with removable blanket type insulation.

8.1.8.2 Removable blanket insulation shall consist of glass fiber insulation with high temperature waterproof covering and stainless steel mesh as a minimum.

8.1.8.3 Subcontractor shall submit his proposed design, thickness, material and method of construction to Contractor for approval.

8.2 Application of Weatherproofing

8.2.1 General

8.2.1.1 All external surfaces of insulation, both indoor and outdoor, shall have a weather barrier finish to keep insulation dry and provide mechanical protection to insulated system.

8.2.1.2 Thickness and Corrugation of Metal Jacketing shall be as follows.

- Aluminum sheet 0.020 in. (0.5 mm) thick flat shall be used on all piping.
- Aluminum sheet 0.020 in. (0.5 mm) thick flat shall be used on horizontal equipment and vertical equipment 760 mm (30 in.) diameter and below.
- Aluminum sheet 0.020 in. (0.5 mm) by 1 ¼ in. (30 mm) corrugated shall be used on vertical equipment above 30 in. (760 mm) diameter.
- Aluminum sheet 0.024 in. (0.6 mm) thick flat shall be used for all irregular surfaces like equipment heads, pump covers, valve covers, fitting covers, etc.
- Stainless steel 0.010 in. (0.25 mm) thick flat shall be used for all piping, all horizontal equipment and vertical equipment 30 in. (760 mm) diameter and below.
- Stainless steel 0.010 in. (0.25 mm) thick by 1 ¼ in. (30 mm) corrugated shall be used for vertical equipment above 30 in. (760 mm) diameter.
- Stainless Steel 0.16 in. (0.4 mm) thick flat shall be used for all irregular shape and fittings.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 15 of 53

- 8.2.1.3 Pipe and equipment operating above 1000°F (538°C) shall be weatherproofed with jacketing without moisture barring backing paper.
- 8.2.1.4 Stainless steel shall be used for stainless steel lines and equipment and carbon steel surfaces operating above 1100°F (593°C).
- 8.2.1.5 All jacket joints or openings shall be fabricated with proper overlaps and installed to prevent moisture penetration.
- 8.2.1.6 All joints shall be sealed where moisture can penetrate. The caulking material shall be per Attachment V, Material Code A-4.
- 8.2.2 Weatherproofing for Piping
 - 8.2.2.1 Installed metal jacketing and mastic shall keep insulation system weathertight during application and operation. Metal joint design shall not rely on caulking compound to keep the system dry.
 - 8.2.2.2 Jacketing for horizontal and vertical cylindrical piping shall have minimum 2 in. (50 mm) circumferential and longitudinal laps.
 - 8.2.2.3 The longitudinal lap on horizontal piping shall be between four o'clock and eight o'clock position to shed rain water.
 - 8.2.2.4 On vertical piping, the upper course of jacketing shall overlap the lower course of jacketing.
 - 8.2.2.5 On vertical pipes, upper courses shall be supported by "S" clips on maximum 12 in. (300 mm) circumferential centers.
 - 8.2.2.6 Preformed aluminum or stainless steel elbow shall be used up to 12 in. (300 mm) OD of insulation. Preformed elbows shall be secured with band on 12 in. (300 mm) center but not less than three per elbow. Where preformed elbow is not available, gored elbow shall be used. Gored elbow shall be secured with one band for each gore.
 - 8.2.2.7 Jacketing shall be secure with 1/2 in. (13 mm) wide stainless steel bands on 12 in. (300 mm) centers.
 - 8.2.2.8 Flat metal jacketing 0.024 in. (0.6 mm) thick shall be used over flanges and flanged fittings.
 - 8.2.2.9 All protrusions including pipe supports and attachments through metal jacketing shall have flashing collar and shall be caulked with high temperature caulking compound to prevent intrusion of moisture.
- 8.2.3 Weatherproofing of Equipment
 - 8.2.3.1 Jacketing shall be applied with 3 in. (75 mm) overlaps on all seams. On vertical vessels, provide a minimum of two corrugations overlap.
 - 8.2.3.2 On vertical vessel, upper course of jacketing shall be supported by S-clips, 0.040 in. (1 mm) thick, on 18 in. (450 mm) centers.
 - 8.2.3.3 Jacketing shall be secured with 3/4 in. (19 mm) bands on 12 in. (300 mm) centers. A band shall be installed over circumferential lap. To prevent bands from sliding on vertical vessels, U-clips, 0.020 in. (0.5 mm) thick, shall be installed on maximum of 48 in. (1220 mm) centers.
 - 8.2.3.4 Vessels over 8 ft. (2.4 m) in diameter or four ft in diameter when operating 400°F (204°C) or higher and all vessels in cyclic service shall have a breather spring (Attachment IX, S-2) per every 24 ft. (7.3 m) length of band.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 16 of 53

- 8.2.3.5 Sheet metal screws if required shall be installed on longitudinal joints at 6 in. (150 mm) centers to hold down jacketing. The metal screws shall not be installed on circumferential lap.
- 8.2.3.6 Insulation of equipment heads shall be covered with finishing cement prior to installation of metal gores.
- 8.2.3.7 Install metal gores at the top head of vertical equipment and both heads of horizontal equipment using sheet metal screws or pop rivets on 6 in. (150 mm) centers. Metal gores shall overlap shell jacketing by a minimum of 4 in. (100 mm).
- 8.2.3.8 Metal gore joints on top head of vertical vessels shall be sealed with caulking compound.
- 8.2.3.9 Bottom head of vertical equipment with the skirt shall be weatherproofed using insulating cements, glass fabric and mastic. After insulating cement is set, apply 1/8 in. (3 mm) thick weatherproofing mastic. While weatherproofing mastic is tacky, a woven glass fabric reinforcing membrane shall be tightly embedded into it and smoothed out to avoid wrinkles and voids. After first coat is dry, a second coat of weatherproofing mastic 1/8 in. (3 mm) thick shall be applied.
- 8.2.3.10 All protrusions through metal jacketing shall have a flashing collar and shall be caulked with high temperature caulking compound to prevent intrusion of moisture.

9.0 INSPECTION

- 9.1 All materials shall be subject to inspection by the Contractor. Any material not meeting requirements of this specification will be rejected and shall be replaced immediately with the specified type and quality by the Subcontractor at no additional cost to the Contractor.

Subcontractor shall furnish a sample of each product he intends to use on the project for Contractor's approval.

Subcontractor personnel shall not walk on or support scaffolding on insulated lines. Any such damage shall be repaired by the Subcontractor at his expense.
- 9.2 Insulation material will be judged defective for any of the following:
 - Presence of cracks extending through the insulation and broken insulation
 - Insulation ends are broken or damaged
 - When more than ten (10) percent of the insulating surface area is composed of large void, 1 in. (25 mm) diameter or larger
 - When large void has a depth greater than ten (10) percent of the insulation thickness
- 9.3 Subcontractor's installation procedure shall be subjected to inspection at all times. Any material found to have been damaged or improperly installed shall be removed and reinstalled promptly at the Subcontractor's expense, unless the damaged was caused by others.
- 9.4 Subcontractor shall apply the finish covering as soon as possible after the insulation has been secured. If it cannot be finished before the end of the working day, the system shall be protected to prevent the insulation from becoming wet.
- 9.5 Insulation must be thoroughly dry at the time of weatherproofing.
- 9.6 Insulation system is defective when:

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 17 of 53

- 9.6.1 The cladding/weatherproofing finish is not water tight.
- 9.6.2 Weatherproofing design which can allow rain water to enter into the insulated system.
- 9.6.3 Presence of hot spots detected after start-up.
- 9.7 Pipe insulation shall have a tolerance of $\pm 1/8$ in. (3 mm) on length and shall be sized for a snug fit over pipe.

10.0 ATTACHMENTS

  Refineria de Cartagena S.A.	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 18 of 53

INDEX OF ATTACHMENTS

ATTACHMENT I	MATERIALS FOR INSULATION REQUIREMENTS CODES H, P, S, E AND R
ATTACHMENT II	INSULATION THICKNESS TABLE FOR PERSONNEL PROTECTION, (P)
ATTACHMENT III	INSULATION THICKNESS TABLE FOR NORMAL HEAT CONSERVATION (H); STEAM TRACING (S); ELECTRIC TRACING (E); AND CONTROTRACE (R)
ATTACHMENT IV	MULTILAYER SCHEDULE
ATTACHMENT V	JOINTING MATERIALS AND MANUFACTURERS
ATTACHMENT VI	FASTENING DEVICES AND MANUFACTURERS
ATTACHMENT VII	COATING ACCESSORIES AND MANUFACTURERS
ATTACHMENT VIII	JACKETING, ACCESSORIES AND MANUFACTURERS
ATTACHMENT IX	INSULATION AND JACKETING SECUREMENTS AND MANUFACTURERS
ATTACHMENT X	INSULATION SUPPORTS AND INSULATION EXPANSION JOINTS FOR VERTICAL PIPING (INSULATION SUPPORTS)
ATTACHMENT XI	INSULATION EXPANSION JOINT FOR HORIZONTAL PIPING
ATTACHMENT XII	INSULATION DETAILS FOR FLANGES AND VALVES
ATTACHMENT XIII	INSULATION DETAILS - VERTICAL EQUIPMENT
ATTACHMENT XIV	INSULATION DETAILS - VERTICAL EQUIPMENT TOP HEADS
ATTACHMENT XV	INSULATION DETAILS - VERTICAL EQUIPMENT SKIRTS
ATTACHMENT XVI	INSULATION DETAILS - HORIZONTAL EQUIPMENT
ATTACHMENT XVII	METAL JACKET DETAILS FOR EQUIPMENT
ATTACHMENT XVIII	JACKETING FOR HEADS HORIZONTAL AND VERTICAL EQUIPMENT
ATTACHMENT XIX	INSULATION DETAILS FOR LEVEL CONTROLLERS
ATTACHMENT XX	INSULATION DETAILS - PIPE EXPANSION JOINTS
ATTACHMENT XXI	FLASHING DETAILS FOR UNINSULATED NOZZLES
ATTACHMENT XXII	INSULATION DETAILS FOR REMOVABLE MANHOLE AND HANDHOLE COVER

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 19 of 53

ATTACHMENT I

MATERIALS FOR INSULATION REQUIREMENTS CODES H, P, S, E AND R

Material Code

I. Mineral Wool Pipe covering (For H & P)

Pipe sections shall conform to ASTM-C547, Type II for use to 1200°F (650 °C), 8 lb/ft³ (128 kg/m³) minimum delivered density without adjusting for shot content with following amendments:

- a. Composition - Only natural mineral substances may be used as raw materials. Mineral wool made from slag are not acceptable because of their high impurity content. Asbestos-containing materials are not acceptable.
- b. Dimensions - Individual dimensions and nesting thicknesses shall be in accordance with ASTM C-585. The inside diameter of the pipe sections shall be slightly oversized (approximately 2 mm) in order to avoid gaps in hot service.
- c. Shot Content - Cumulative Shot (non-fibrous material) content through 100 mesh (150 micron) sieve shall not exceed 20% by weight when tested per ASTM C-1335. No downside tolerance from 20% shall be made.
- d. Thermal Conductivity - Thermal conductivity shall be measured per ASTM C-335 and shall not exceed maximum values listed as below:

<u>Mean Temperature °F (°C)</u>	<u>Thermal Conductivity Btu.in/ft°-h°F (W/mK)</u>
92 (50)	0.27 (0.039)
212 (100)	0.305 (0.044)
302 (150)	0.347 (0.050)
392 (200)	0.395 (0.057)
482 (250)	0.451 (0.065)
572 (300)	0.52 (0.075)
662 (350)	0.630 (0.087)

- e. Chloride Content - The chloride content of the insulation material shall be per ASTM C795 and test procedures describes in ASTM C871.
- f. Combustibility - The insulation material shall be non-combustible in accordance with the procedure listed in ASTM E-136.
- g. Flame Spread and Smoke Development - The insulation material shall have a maximum flame spread index of 5, fuel contribution of 5 and smoke development of 5.
- h. Water Repellency - The insulation material shall be water repellent. When tested in accordance with BS2972, the water absorption shall be no more than 1% by volume. (This property is desired to minimize the cost of jobsite protection of insulation material from rain water and high humidity).
- i. There shall be no adjustment in the minimum specified density due to shot content.
- j. The acceptable manufacturers are:

<u>Manufacturers</u>	<u>Brand Names</u>	<u>Temp. Limitations</u>
Lapinus	Lapinus 851	1200 °F (650°C)
Owens Corning	High Temperature Pipe Insulation	1200 °F (650°C)

- k. Manufacture shall certify above properties and submit certification to Contractor.

  Refinería de Cartagena S.A.	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 20 of 53

ATTACHMENT I

MATERIALS FOR INSULATION REQUIREMENTS CODES H, P, S, E AND R (Continued)

II Mineral Wool Block and Board (For H & P)

The block and board shall comply with the following minimum requirements:

- The block and board shall be furnished in accordance with ASTM C-612, Type IV and shall be rated for 1200 °F (650°C) continuous use temperatures.
- The block and board shall have a minimum density of 10 lb/ft³ (160 kg/m³). Cumulative Shot (non-fibrous material) content through 100 mesh (150 micron) sieve shall not exceed 20% by weight when tested per ASTM C-1335. No downside tolerance from 20% shall be made.
- Material composition, flammability, chloride content, combustibility, water repellency requirements shall be the same as the requirements listed in the pipe section.
- The acceptable manufacturer's are:

<u>Manufacturers</u>	<u>Brand Names</u>	<u>Temp. Limitations</u>
Lapinus	Tank Roof Slab 523	1200 °F (650°C)
Owens Corning	High Temperature Industrial Board Insulation Type 1210	1200 °F (650°C)

III Mineral Wool Wire Mesh Blanket (For H & P)

The wired mats shall comply with the following minimum requirements:

- The wired mat (metal mesh blanket) shall be furnished in accordance with ASTM C-592 Type II and shall be rated for 1200 °F (650°C) continuous use temperature.
- Mineral wool blanket shall have a nominal density of 8 lb/ft³ (128 kg/m³) (without wire mesh), with cumulative shot (non-fibrous material) content through 100 mesh (150 micron) sieve shall not exceed 20% by weight when tested per ASTM C-1335. No downside tolerance from 20% shall be made.
- Wire mesh facing shall be austenitic stainless steel or monel if used over austenitic stainless steel, nickel or nickel alloy piping and equipment surfaces and galvanized steel when applied over ferritic piping and equipment surfaces.
- Material composition, flammability, chloride content, combustibility, water repellency requirements shall be the same as the requirements listed in the pipe section.
- The acceptable manufacturer's are:

<u>Manufacturers</u>	<u>Brand Names</u>	<u>Temp. Limitations</u>
Lapinus	Wired Mat 159	1200 °F (650°C)
Owens Corning	High Temperature Flexible	1200 °F (650°C))
	Batt	Type 1280

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 21 of 53

ATTACHMENT I

MATERIALS FOR INSULATION REQUIREMENTS CODES H, P, S, E AND R (Continued)

IV Cellular Glass (For S, E & R Service)

- a. Cellular glass block and pipe insulation shall be a borosilicate glass foamed to form a rigid unicellular, closed cell material conforming to ASTM C552 and Annexes along with the following additional requirements.
 - a.1 Physical Properties (Exceptions to C552-91)
 - a.1.1 Thermal Conductivity when tested per ASTM-C 177 and C518 shall not be more than:
 - 0.28 BTU-in/hr.ft² °F @ 50°F (0.038 W/mK @ 0°C)
 - 0.29 BTU-in/hr.ft² °F @ 75°F (0.039 W/mK @ 10°C)
 - a.1.2 Compressive strength when tested per ASTM C240 and C165 shall not be less than 100 psi (7 kg/cm²).
 - a.1.3 All other properties shall be ASTM (C552-91 and annexes).
 - a.2 Pipe sections and blocks shall be fabricated in 24 in. (610 mm) lengths. Shorter sections are not acceptable.
 - a.3 Prior to shipment of cellular glass to the jobsite, Contractor's inspectors shall have free access to manufacturing facility to check cellular glass production, fabrication (if any) and witness ASTM designated properties testing.
 - a.4 Before commencing any insulation work, insulation Subcontractor/material supplier shall submit data sheets and samples of the material he intends to use on the project for Contractor's approval.
 - a.5 Fabrication adhesive shall be U. S. Gypsum Co. "Hydrocal B-11".
- b. Density of cellular glass shall be 7 lb/ft³ (112 kg/m³)
- c. Cellular Glass Block and Pipe Thermal Insulation Compliance with ASTM C-552 Type I, II and III

<u>Manufacturers</u>	<u>Brand Names</u>	<u>Temperature Limitations</u>
Pittsburgh – Corning	Foamglass	300°F (149°C)

V Expanded Perlite (for H and P) Insulation for Modules Work

- a. Preformed expanded perlite insulation shall be used for piping and equipment in Heat Conservation (H) and Personnel Protection (P) in lieu of mineral wool.
 - a.1 The expanded perlite shall meet the following requirements:
 - a.2 Block and pipe covering shall be suitable for a temperature of 649°C (1200°F), and confirming to ASTM C610.
 - a.3 Minimum density shall be 192 kg/m³ (12 lb/ft³).
 - a.4 Sectional (two-piece or quads) pipe covering shall be used for all commercially available sizes.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 22 of 53

ATTACHMENT I

MATERIALS FOR INSULATION REQUIREMENTS CODES H, P, S, E AND R

(Continued)

- a.5 All other pipe sizes and for all equipments, insulation shall be curved radius or scored blocks. Width of block shall not be less than 150 mm (six inches).
- a.6 The following manufacturers are acceptable:
 - Industrial Insulation Group, LLC Sproule WR-1200
 - Howred Corp. Goodtemp

  Refinería de Cartagena S.A.	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 23 of 53

ATTACHMENT II

INSULATION THICKNESS TABLE FOR
PERSONNEL PROTECTION, (P)

INSULATION MATERIAL: MINERAL WOOL

TEMPERATURE °F

NOMINAL PIPE SIZE	70 TO 300	301 TO 400	401 TO 600	601 TO 800	801 TO 1000	1001 TO 1100	1101 TO 1200	1201 TO 1300	1301 TO 1400	1401 TO 1500
INSULATION THICKNESS IN INCHES										
1-1/2" & SMALLER	1	1	1-1/2	2-1/2	3	3-1/2	3-1/2	4	4-1/2	4-1/2
2"	1	1	2	2-1/2	3	3-1/2	4	4	4-1/2	5
3"	1	1	2	2-1/2	3-1/2	3-1/2	4	4-1/2	5	5-1/2
4"	1	1	2	2-1/2	3-1/2	4	4-1/2	5	5	5-1/2
6"	1	1-1/2	2	3	3-1/2	4	4-1/2	5	5-1/2	6
8"	1-1/2	1-1/2	2	3	4	4-1/2	5	5-1/2	6	6-1/2
10"	1-1/2	1-1/2	2	3	4	4-1/2	5	5-1/2	6	7
12"	1-1/2	1-1/2	2	3	4	4-1/2	5	6	6-1/2	7
14"	1-1/2	1-1/2	2	3	4	4-1/2	5-1/2	6	6-1/2	7
16"	1-1/2	1-1/2	2	3	4	5	5-1/2	6	6-1/2	7-1/2
18"	1-1/2	1-1/2	2-1/2	3	4-1/2	5	5-1/2	6	6-1/2	7-1/2
20"	1-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5	5-1/2	6	7	7-1/2
24"	1-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5	5-1/2	6-1/2	7	8
30"	1-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5	6	6-1/2	7	8
36"	1-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2	6	6-1/2	7-1/2	8
OVER 36" TO FLAT	1-1/2	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2	6	6-1/2	7-1/2	8
SINGLE LAYER					MULTIPLE LAYERS					

NOTES:

1. Thickness of insulation will keep surface temperature below 150°F (66°C) using emittance of 0.3, wind 0 m/h and ambient temperature of 80°F (27°C).



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 24 of 53

ATTACHMENT III

INSULATION THICKNESS TABLE FOR HEAT CONSERVATION (H); STEAM TRACING (S); ELECTRIC TRACING (E); AND CONTROTRACE (R)

INSULATION MATERIAL

Insulation Type H Service - MINERAL WOOL

Insulation Type S E & R Service – CELLULAR GLASS

TEMPERATURE °F

NOMINAL PIPE SIZE	70 TO 300	301 TO 400	401 TO 600	601 TO 800	801 TO 1000	1001 TO 1100	1101 TO 1200	1201 TO 1300	1301 TO 1400	1401 TO 1500
	INSULATION THICKNESS IN INCHES									
1-1/2" & SMALLER	1-1/2	1-1/2	2	3	3-1/2	3-1/2	4	4	4-1/2	4-1/2
2"	1-1/2	1-1/2	2	3	3-1/2	3-1/2	4	4	4-1/2	5
3"	1-1/2	2	2-1/2	3-1/2	3-1/2	4	4	4-1/2	5	5-1/2
4"	1-1/2	2	2-1/2	3-1/2	4	4	4-1/2	5	5-1/2	6
6"	2	2	3	3-1/2	4	4-1/2	4-1/2	5	5-1/2	6
8"	2	2-1/2	3	4	4-1/2	4-1/2	5	5-1/2	6	6-1/2
10"	2	2-1/2	3	4	4-1/2	5	5	5-1/2	6	7
12"	2	2-1/2	3-1/2	4	5	5-1/2	5-1/2	6	6-1/2	7
14"	2	2-1/2	3-1/2	4-1/2	5	5-1/2	6	6	6-1/2	7
16"	2	2-1/2	3-1/2	4-1/2	5	5-1/2	6	6	6-1/2	7-12
18"	2-1/2	3	3-1/2	4-1/2	5-1/2	5-1/2	6	6	7	7-12
20"	2-1/2	3	3-1/2	4-1/2	5-1/2	5-1/2	6	6	7	7-12
24"	2-1/2	3	3-1/2	4-1/2	5-1/2	6	6	6-1/2	7	8
30"	2-1/2	3	3-1/2	4-1/2	5-1/2	6	6	6-1/2	7	8
36"	2-1/2	3	3-1/2	4-1/2	5-1/2	6	6	6-1/2	7-1/2	8
OVER 36" TO FLAT	2-1/2	3	4	5	6	6-1/2	7	7	8	8
SINGLE LAYER				MULTIPLE LAYERS						



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 25 of 53

ATTACHMENT IV

MULTILAYER SCHEDULE

Required Thickness of Insulation In (mm)	Inner Layer Thickness In (mm)	Middle Layer Thickness In (mm)	Outer Layers Thickness In (mm)
2 1/2 (65)	1 (25)	NONE	1 1/2 (40)
3 (75)	1 1/2 (40)	NONE	1 1/2 (40)
3 1/2 (90)	1 1/2 (40)	NONE	2 (50)
4 (100)	2 (50)	NONE	2 (50)
4 1/2 (115)	2 (50)	NONE	2 1/2 (65)
5 (125)	2 (50)	NONE	3 (75)
5 1/2 (140)	2 1/2 (65)	NONE	3 (75)
6 (150)	3 (75)	NONE	3 (75)
6 1/2 (165)	3 (75)	NONE	3 1/2 (90)
7 (175)	3 1/2 (90)	NONE	3 1/2 (90)
7 1/2 (190)	3 1/2 (90)	NONE	4 (100)
8 (200)	4 (100)	NONE	4 (100)

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 27 of 53

ATTACHMENT VI

FASTENING DEVICES AND MANUFACTURERS

Material
Code

- B-1 Floating Ring - 3/8 in. (9 mm) diameter carbon steel rod, or T-304 Stainless Steel wire 16 gauge consisting of six wires twisted together.
- B-2 Sheet Metal Screws (pan Head "A" Type or hex head) - Stainless Steel (Type 316) self tapping.
 - a. ITW Insulation System
 - b. RPR Products Co.
- B-3 Pop-rivets Stainless Steel (Type 304)
 - a. ITW Insulation System
 - b. RPR Products Co.

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 28 of 53

ATTACHMENT VII

COATING ACCESSORIES AND MANUFACTURERS

Material
Code

C-1 Breather Mastic Vinyl Acrylic Emulsion

Breather Mastic shall have the following properties:

- | | | |
|----|---|--|
| a. | Average Non –Volatile | 63 to 65% |
| b. | Service temperature | 20°F to 200°F (-29°C to 93°C) |
| c. | Surface burning characteristics (ASTM E84) | Flame Spread 20, Smoke Developed 25-50 |
| d. | Water Vapor Permeance (ASTM F 1249) 2.0 metric perm (3.0 perm) at 1/16 in (1.6mm) DFT | |

The following are acceptable material:

- | | | |
|----|--------------------|---------------|
| a. | Foster Division | Aquafes 35-01 |
| b. | Pittsburgh Corning | Pittcote 404 |

C-2 1 in. (25 mm) Hex Mesh, Stainless Steel, 0.019 in. (0.5 mm)

- | | |
|----|-----------------------|
| a. | ITW Insulation System |
| b. | RPR Products Co. |

C-3 Glass Cloth, Approximately 36 in. (910 mm) wide, Starched, 10 x 10 Mesh

- | | | |
|----|-----------------------|------------------------|
| a. | Insul-Coustic Company | IC 10 x 10 Glass Cloth |
| b. | Owens Corning | Fiberglass-Cloth |
| c. | Foster | Mast-A-Fab |

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 29 of 53

ATTACHMENT VIII

JACKETING, ACCESSORIES AND MANUFACTURERS

Material
Code

- J-1 Aluminum jacketing shall be plain, smooth finish, with heat sealed three mils thick backing layer of Polysurlyn (co-extrusion of polyethylene and DuPont's Surlyn). Nominal thickness shall be 0.020 in. (0.5 mm) and 0.024 in. (0.6 mm), 3105-H14, 3003-H14 or 5005-H14 Alloy and temper.
- b. RPR Co.
 - c. ITW Insulation System, Pabco-Childers Metals
- J-2 Aluminum jacketing shall be plain, corrugated finish, with heat sealed three mils thick backing layer of Polysurlyn (co-extrusion of polyethylene and DuPont's Surlyn). Nominal thickness shall be 0.020 in. (0.5 mm), with 1 1/4 in. (30 mm) corrugations, 3105-H14, 3003-H14 or 5005-H14 Alloy and temper.
- a. RPR Co.
 - b. ITW Insulation System, Pabco-Childers Metals
- J-3 Stainless Steel ASTM A167, Type A151-304 No. 1 finish. Nominal thickness shall be 0.010 in. (0.25 mm) and 0.016 in. (0.4 mm) smooth jacketing with heat sealed three mils thick backing layer of Polysurlyn (co-extrusion of polyethylene and DuPont's Surlyn) moisture barrier.
- a. RPR Co.
 - b. ITW Insulation System, Pabco-Childers Metals
- J-4 Stainless Steel shall be ASTM A167 Type A-151-304 No. 1 finish. Nominal thickness shall be 0.010 in. (0.25 mm) with 1 1/4 in. (30 mm) corrugation.
- a. RPR Co.
 - b. ITW Insulation System, Pabco-Childers Metals

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 30 of 53

ATTACHMENT IX

INSULATION AND JACKETING SECUREMENTS AND MANUFACTURERS

**Material
Code**

- S-1 Bands and Seals - Stainless Steel (Type 316)
 Sizes: 1/2 in. (13 mm) wide by 0.020 in. (0.5 mm) thick
 3/4 in. (19 mm) wide by 0.020 in. (0.5 mm) thick
- b. RPR Products Co.
 c. ITW Insulation System, Pabco-Childers Metals
- S-2 Stainless Steel Wire, T-316, 16 gauge
- S-3 Breather Springs
- a. RPR Products Co. - No. 7
 b. ITW Insulation System, Pabco-Childers Metals - Mighty Springs
- S-4 "S" or "U" Clips - Type 316
 Size: 3/4 in. (19 mm) wide by 0.040 in. (1.0 mm) thick for "S" clips
 3/4 in. (19 mm) wide by 0.020 in. (0.5 mm) thick for "U" clips
- a. RPR Products Company
 b. ITW Insulation System, Pabco-Childers Metals



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:
166000-000-SP-MU10-0004

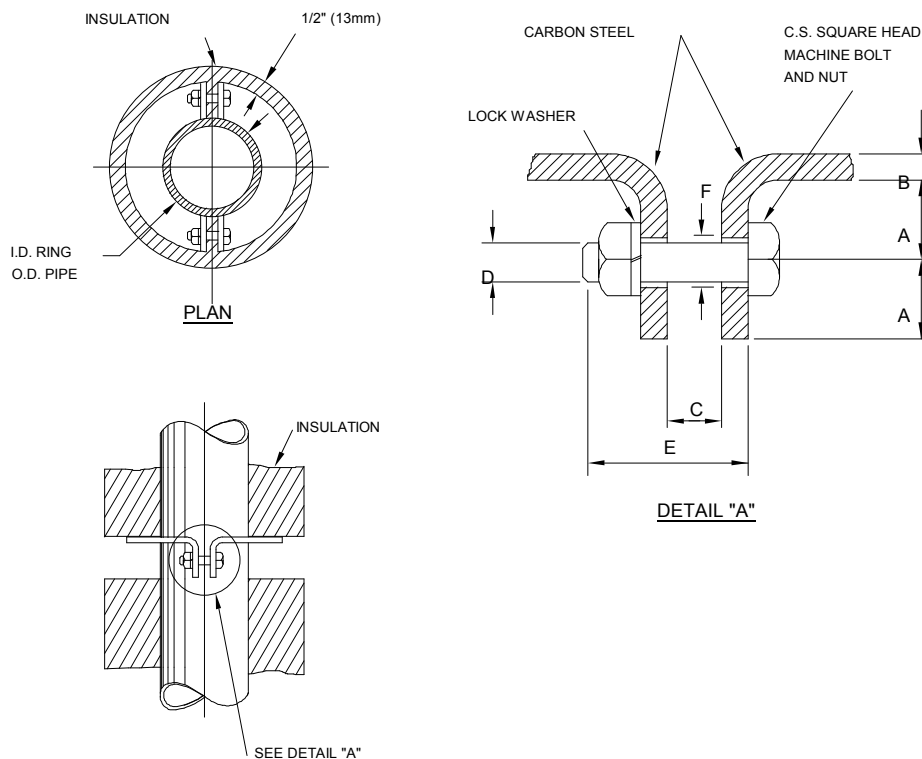
Revision: 4

Date: 21-Feb-11

Page: 31 of 53

ATTACHMENT X

INSULATION SUPPORTS AND INSULATION EXPANSION JOINTS FOR VERTICAL PIPING (INSULATION SUPPORTS)



PIPE SIZE	I.D. RING	SUPPORT DIMENSIONS, INCHES						SUPPORT DIMENSIONS, MM					
		A	B	C	D	E	F	A	B	C	D	E	F
1/2	7/8	1/2	1/8	1/8	1/4	1	3/8	13	3	3	6	25	10
3/4	1-1/16	1/2	1/8	1/8	1/4	1	3/8	13	3	3	6	25	10
1	1-5/16	1/2	1/8	1/8	1/4	1	3/8	13	3	3	6	25	10
1-1/2	1-15/16	1/2	1/8	1/8	1/4	1	3/8	13	3	3	6	25	10
2	2-3/8	3/4	3/16	3/16	3/8	1-1/4	1/2	19	5	5	10	32	13
3	3-1/2	3/4	3/16	3/16	3/8	1-1/4	1/2	19	5	5	10	32	13
4	4-1/2	3/4	3/16	3/16	3/8	1-1/4	1/2	19	5	5	10	32	13
6	6-5/8	3/4	3/16	3/16	3/8	1-1/4	1/2	19	5	5	10	32	13
8	8-5/8	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
10	10-3/4	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
12	12-3/4	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
14	14	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
16	16	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
18	18	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
20	20	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16
24	24	1	1/4	1/4	1/2	1-1/2	5/8	25	6	6	13	38	16

Note: Support material shall be same as piping material and shall be painted as required.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

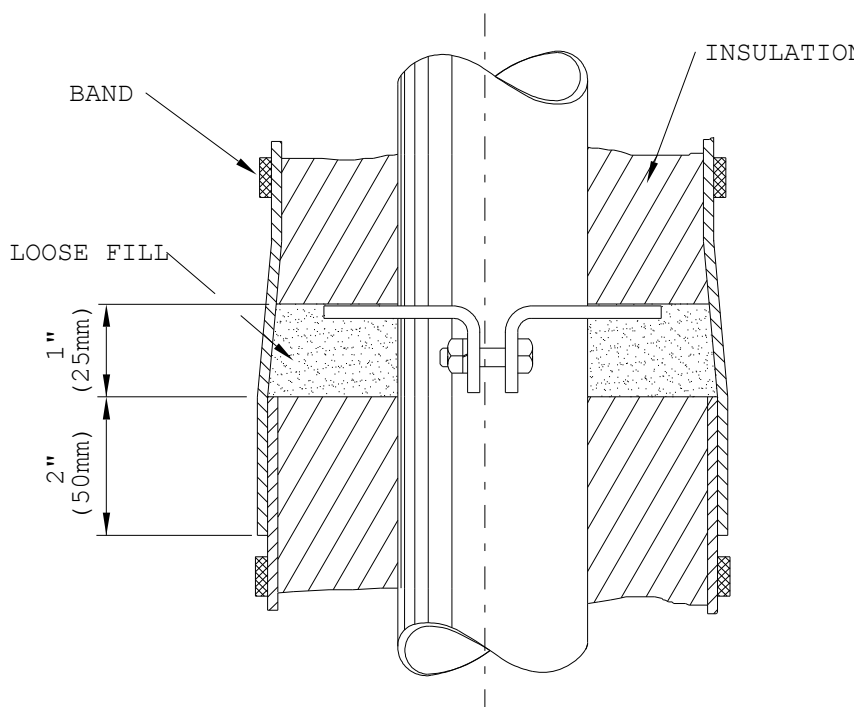
Revision: 4

Date: 21-Feb-11

Page: 32 of 53

ATTACHMENT X

INSULATION SUPPORTS AND INSULATION EXPANSION JOINTS FOR VERTICAL PIPING (INSULATION SUPPORTS) (Continued)





INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

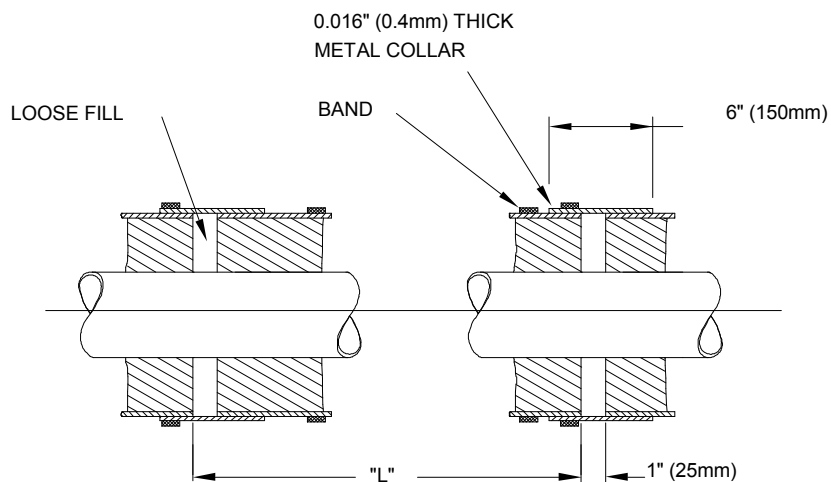
Revision: 4

Date: 21-Feb-11

Page: 33 of 53

ATTACHMENT XI

INSULATION EXPANSION JOINT FOR HORIZONTAL PIPING



EXPANSION JOINT SPACING FOR VERTICAL AND HORIZONTAL PIPING

OPERATING TEMPERATURE		MAXIMUM DISTANCE BETWEEN INSULATION EXPANSION JOINTS	
°C	(°F)	"L" METERS	(FEET)
150 to 300	(66 to 149)	39	(11.9)
301 to 400	(150 to 204)	24	(7.3)
401 to 600	(205 to 316)	18	(5.5)
601 to 800	(317 to 427)	12	(3.7)
801 to 1000	(428 to 538)	9	(2.7)
1001 to 1200	(539 to 649)	6	(1.8)



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

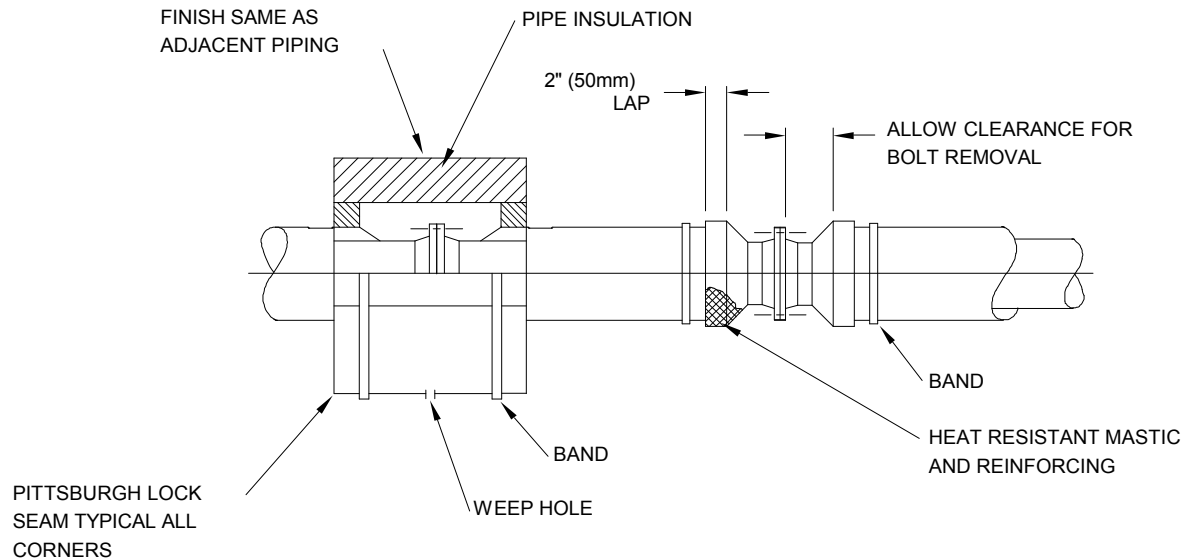
Revision: 4

Date: 21-Feb-11

Page: 34 of 53

ATTACHMENT XII

INSULATION DETAILS FOR FLANGES AND VALVES



INSULATED

FOR PIPING INSULATION
WIRE, JACKET, ETC., SEE
PIPING INSULATION DETAILS.

UNINSULATED

NORMAL HEAT CONSERVATION



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

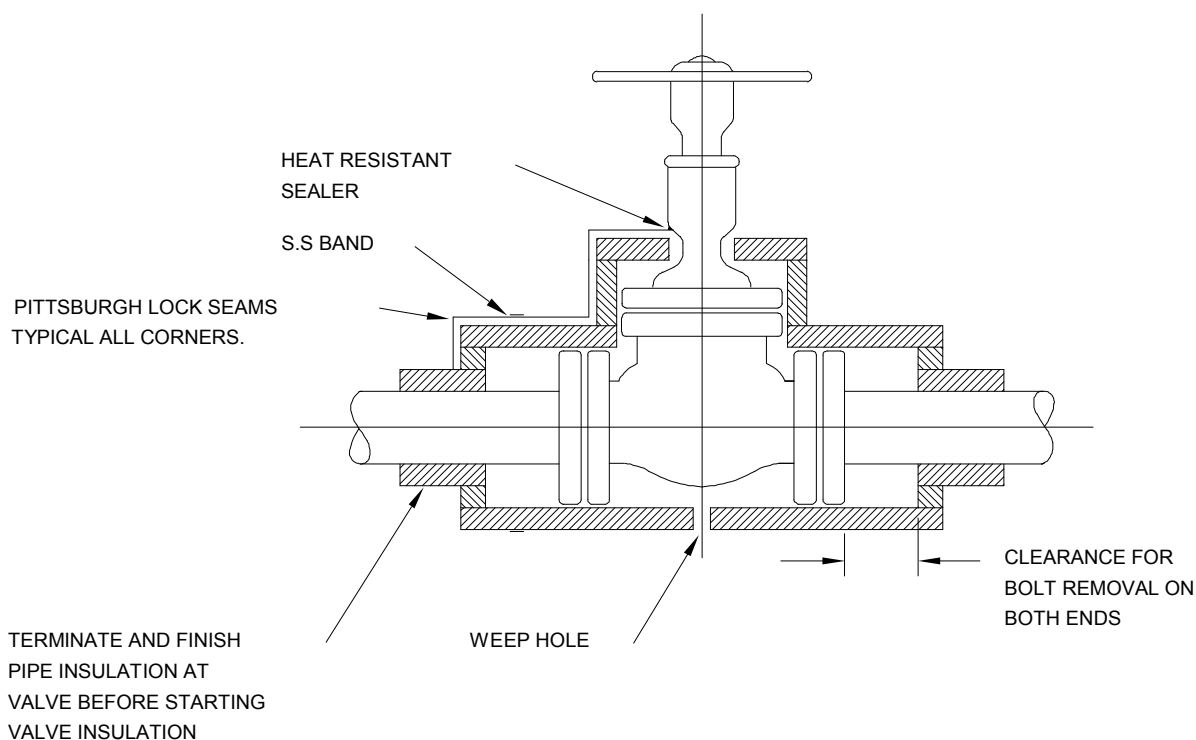
Revision: 4

Date: 21-Feb-11

Page: 35 of 53

ATTACHMENT XII

INSULATION DETAILS FOR FLANGES AND VALVES (Continued)



VALVE INSULATION DETAILS



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

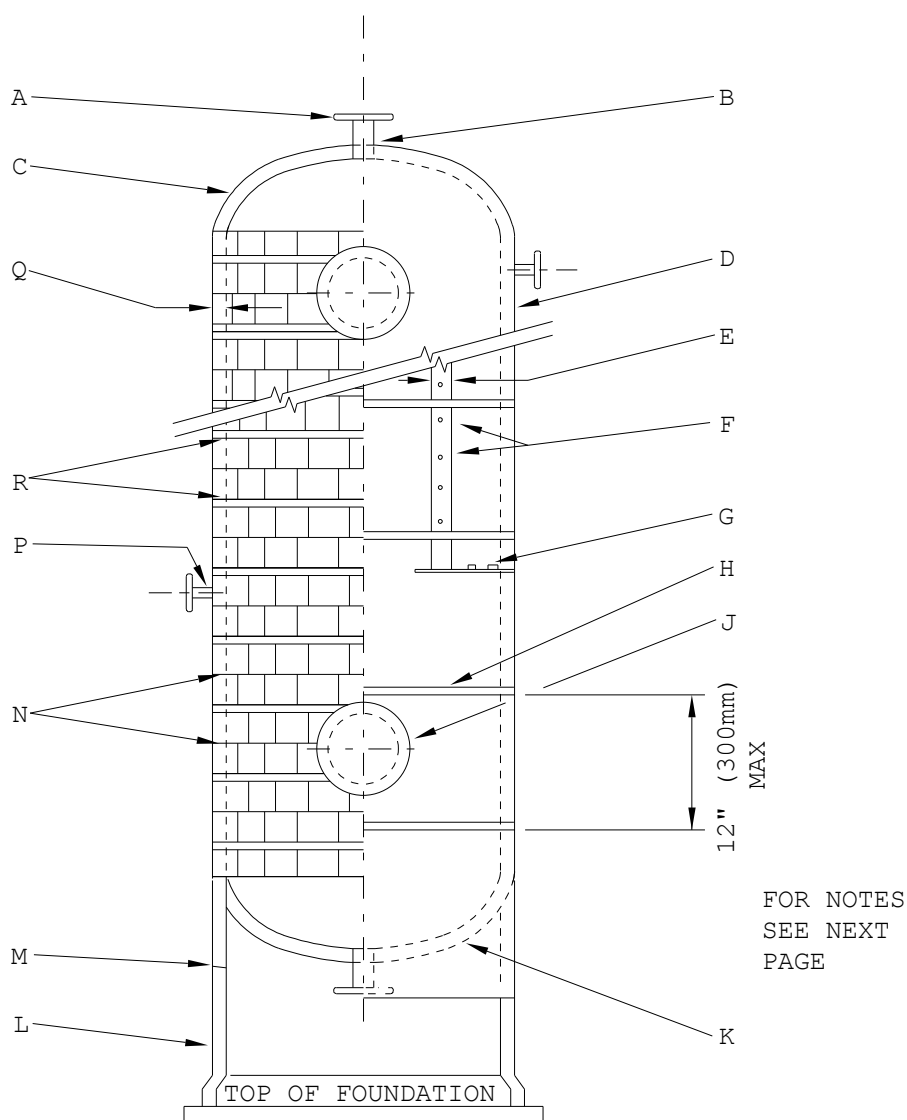
Revision: 4

Date: 21-Feb-11

Page: 36 of 53

ATTACHMENT XIII

INSULATION DETAILS - VERTICAL EQUIPMENT



	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 37 of 53

ATTACHMENT XIII
INSULATION DETAILS - VERTICAL EQUIPMENT
(Continued)

- A. Nozzle insulation.
- B. For detail of floating ring see Attachment XIV.
- C. Insulation thickness on head same thickness as on shell. Secure blocks with 3/4 in. x 0.020 in. (19 mm x 0.5 mm) stainless steel bands and seals spaced 12 in. (300 mm) apart on circumference. Trowel on 1/2 in. (13 mm) thick (dry) coat of quick setting finish cement. Finish on heads: metal jacketing with moisture barrier - See Attachment XIX.
- D. Metal jacketing.
- E. Laps in jacket to be 3 in. (75 mm).
- F. For equipment greater than 30 in. (760 mm) OD sheet metal screws, No. 8 x 1/2 in. (13 mm) long, if required shall be installed on vertical seams at 6 in. (150 mm) centers to hold down jacketing. The metal screws shall not be installed on horizontal seams.
- G. "S" clips at each horizontal seam (see Attachment XVIII).
- H. Stainless steel bands and seals over jacketing, shall be 12 in. (300 mm) apart. (Band size depends on equipment diameter).
- J. Manholes and flanges will not be insulated except where specified. Stiffener rings shall be insulated and encased with aluminum flashing unless otherwise specified.
- K. Insulated bottom head and cover with finishing cement and mastic weatherproofing.
- L. Fireproofing.
- M. Flash and seal (Attachment XVI).
- N. Use staggered joint construction. Seal cracks and joints with insulating cement (Attachment V, Material Code A-4).
- P. Fit metal jacket as close as possible around projections. Seal with heat resistant mastic. (If nozzle temperature exceeds limit of mastic, use flat metal for flashing).
- Q. For type and thickness of shell insulation see equipment schedule.
- R. Stainless steel bands and seals spaced 12 in. (300 mm) apart over insulation.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

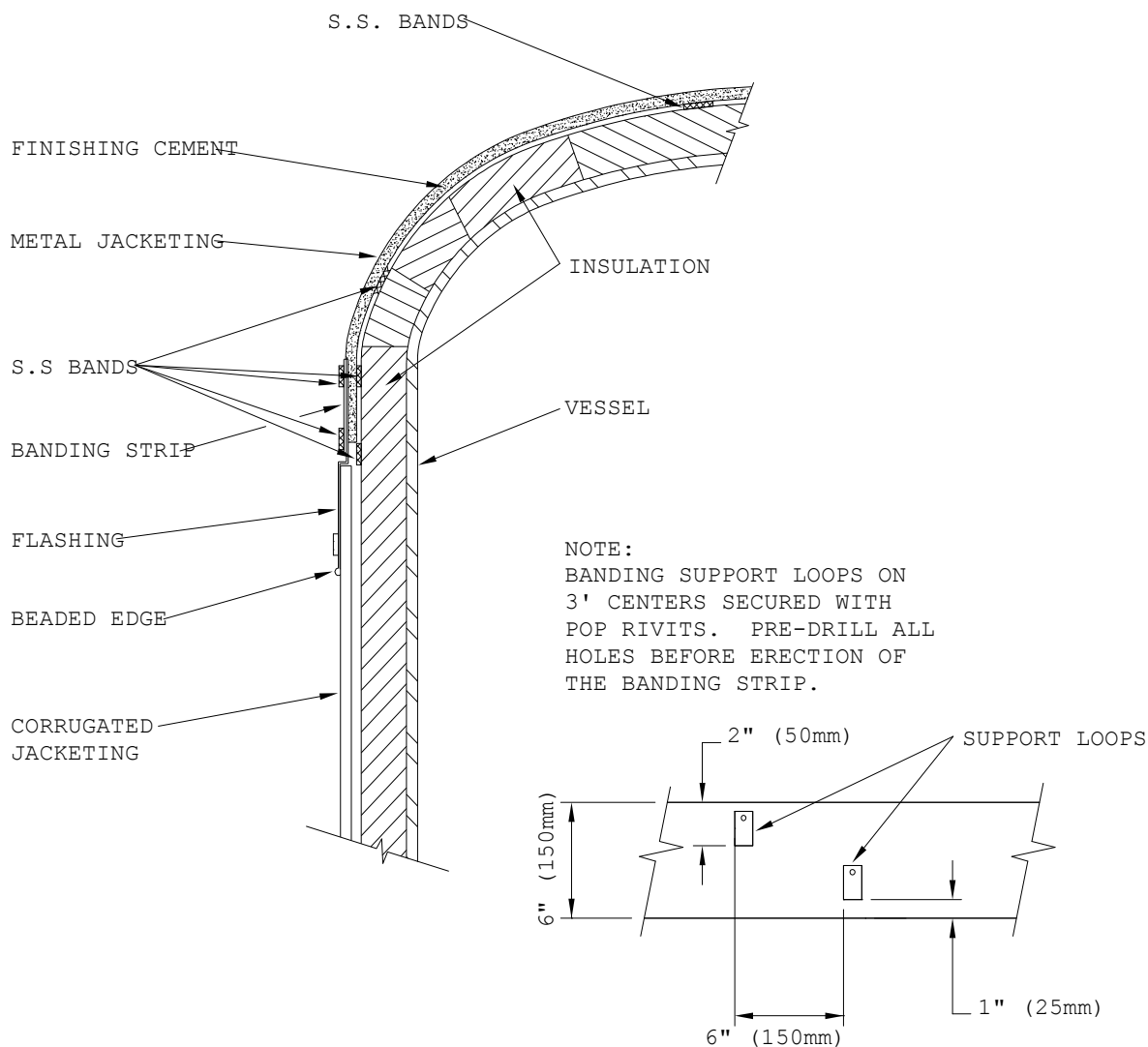
Revision: 4

Date: 21-Feb-11

Page: 38 of 53

ATTACHMENT XIV

INSULATION DETAILS - VERTICAL EQUIPMENT TOP HEADS



BANDING STRIP



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

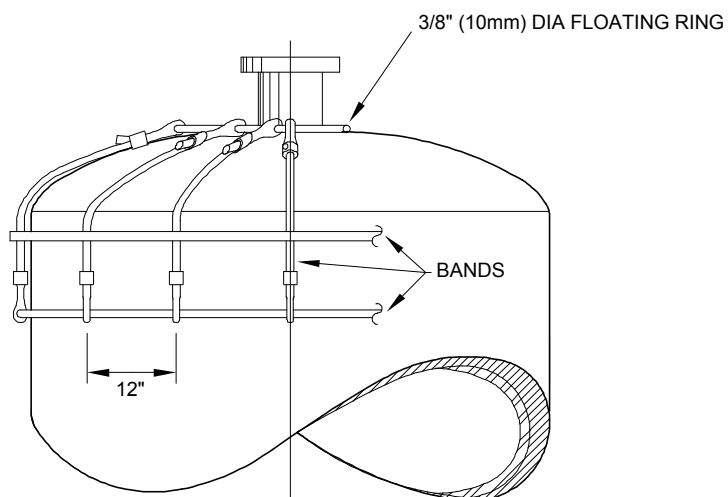
Revision: 4

Date: 21-Feb-11

Page: 39 of 53

ATTACHMENT XIV

INSULATION DETAILS - VERTICAL EQUIPMENT TOP HEADS (Continued)



BLOCK INSULATION ON TOP HEADS



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

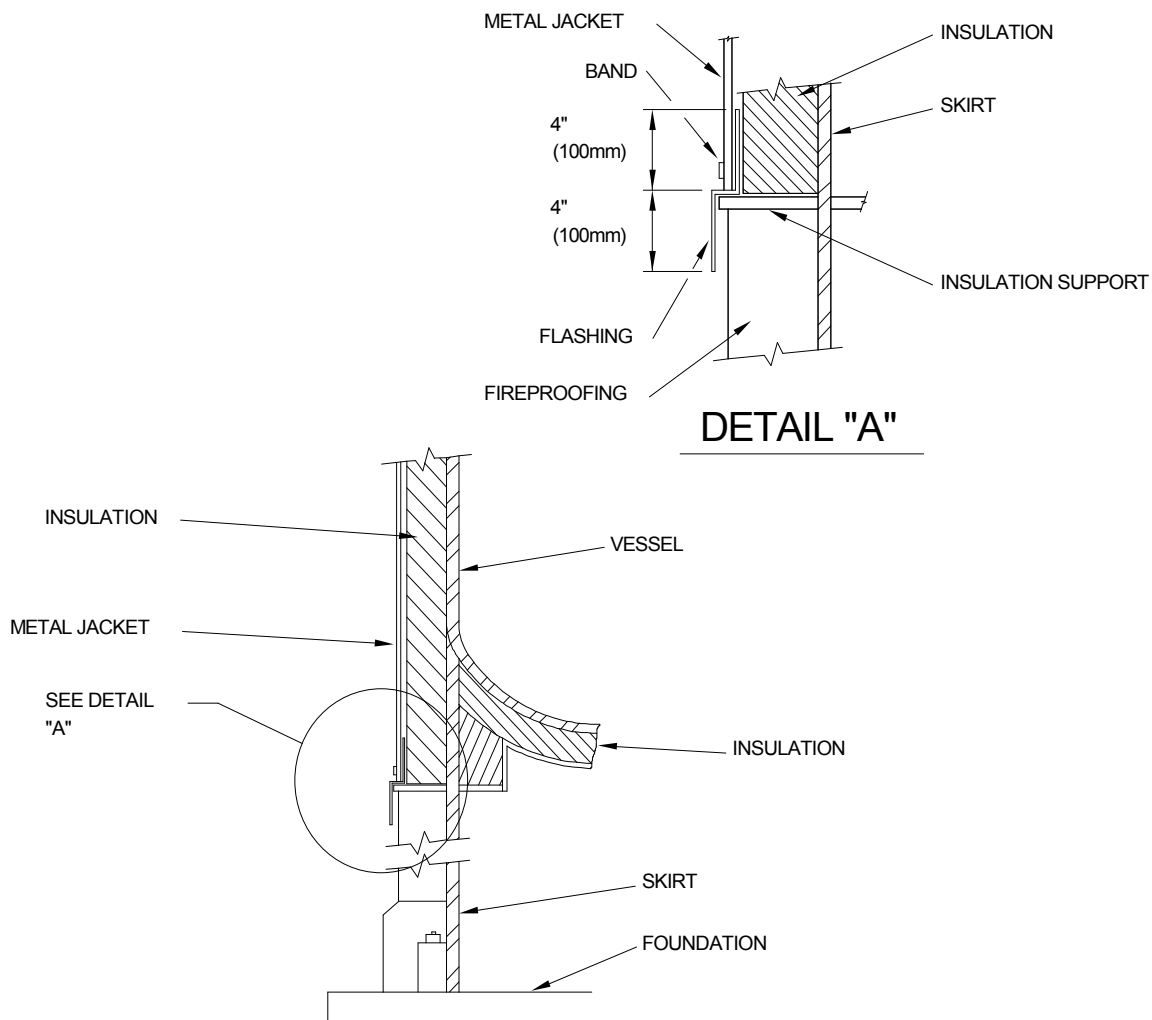
Revision: 4

Date: 21-Feb-11

Page: 40 of 53

ATTACHMENT XV

INSULATION DETAILS - VERTICAL EQUIPMENT SKIRTS





INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

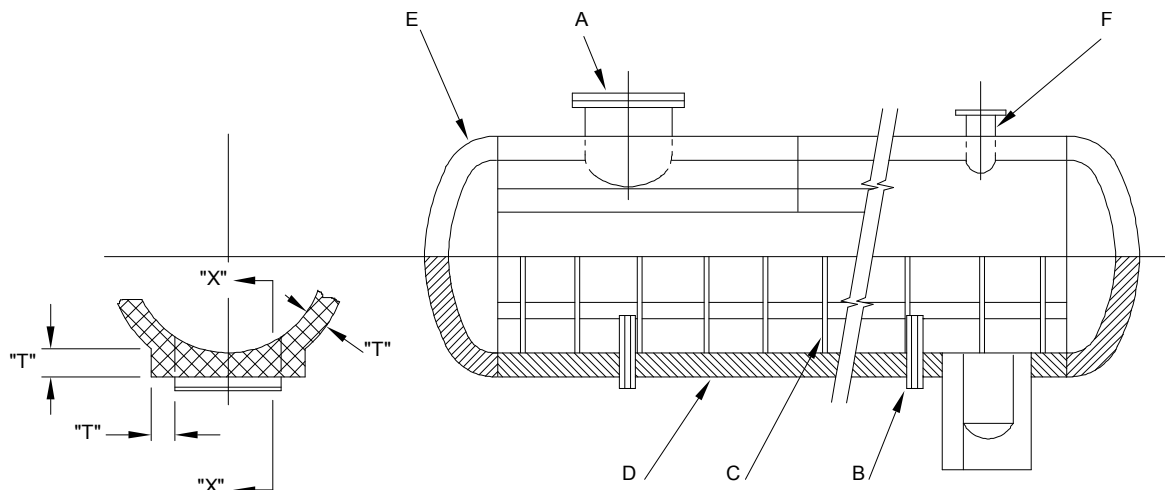
Revision: 4

Date: 21-Feb-11

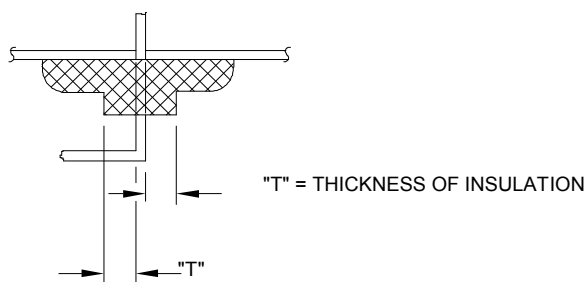
Page: 41 of 53

ATTACHMENT XVI

INSULATION DETAILS - HORIZONTAL EQUIPMENT



INSULATION OF SUPPORT CLIP



SECTION "X-X"

SUPPORT CLIP

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 42 of 53

ATTACHMENT XVI
INSULATION DETAILS - HORIZONTAL EQUIPMENT
(Continued)

NOTES:

- A. Except where specified or noted on the equipment schedule, manholes and flanges will not be insulated.
- B. Fit metal jacket as close as possible around all projections. Seal with heat resistant mastic. (If nozzle temperature exceeds limit of mastic, use flat metal for flashing).
- C. Stainless steel Type 304 bands and seals spaced 12 in. (300 mm) apart over insulation and jacketing.
- D. For type and thickness of shell insulation, see equipment schedule.
- E. Insulation thickness on heads shall be same thickness as on shell. Secure blocks with stainless steel bands and seals 12 in. (300 mm) apart on circumference. Trowel on a 1/2 in. (13 mm) thick (dry) coat of quick setting finishing cement.
- F. For detail of floating ring and insulation at nozzle see Attachment XIV and Attachment XXI respectively.

GENERAL NOTES

- 1. Apply metal jacket over finished insulation.
- 2. Laps in jacket shall be 3 in. (75 mm).
- 3. Use staggered joint construction. Seal voids and cracks with finish cement.
- 4. For equipment 30 in. (760 mm) diameter and smaller, insulate same as shown except use pipe insulation.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

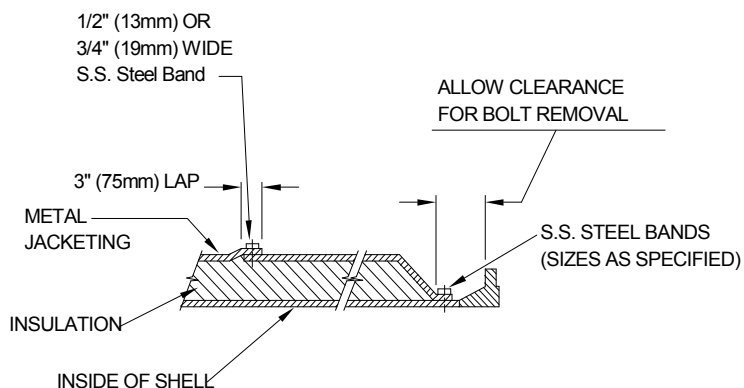
Revision: 4

Date: 21-Feb-11

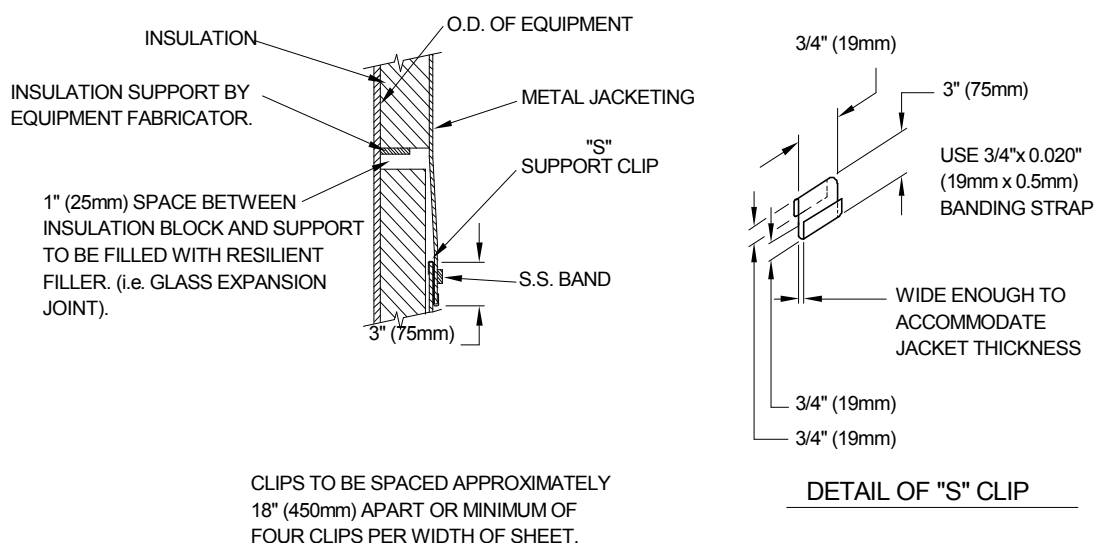
Page: 43 of 53

ATTACHMENT XVII

METAL JACKET DETAILS FOR EQUIPMENT



CIRCUMFERENTIAL SEAM DETAILS HORIZONTAL EQUIPMENT



HORIZONTAL SEAM DETAILS VERTICAL EQUIPMENT



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

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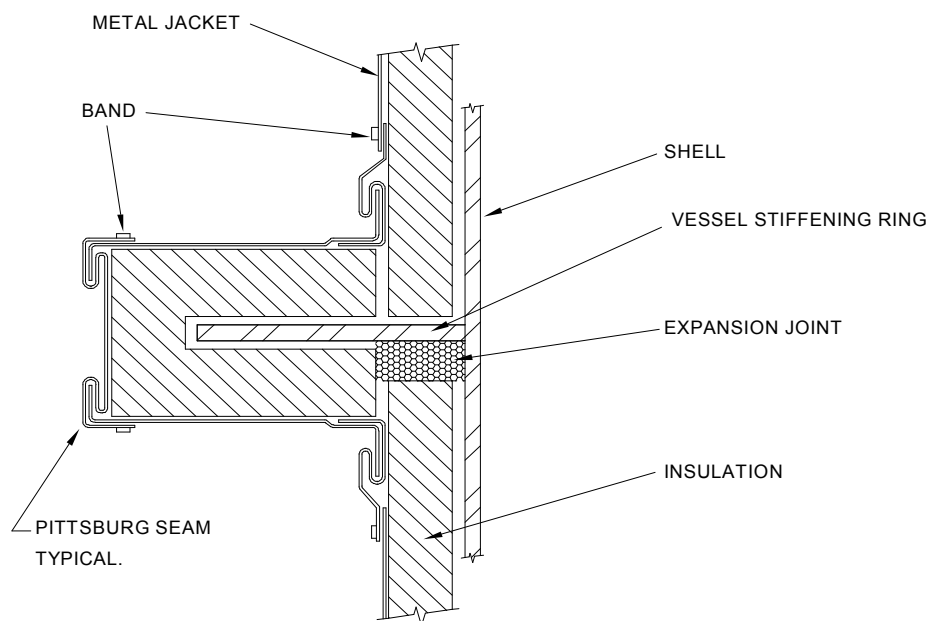
166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 44 of 53

ATTACHMENT XVII METAL JACKET DETAILS FOR EQUIPMENT (Continued)





INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

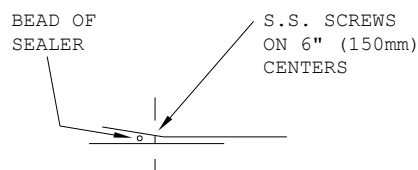
Revision: 4

Date: 21-Feb-11

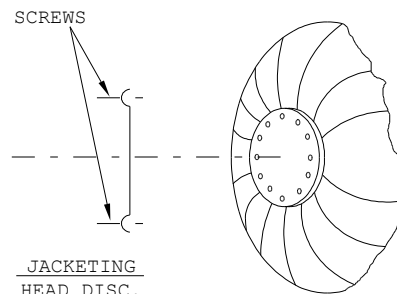
Page: 45 of 53

ATTACHMENT XVIII

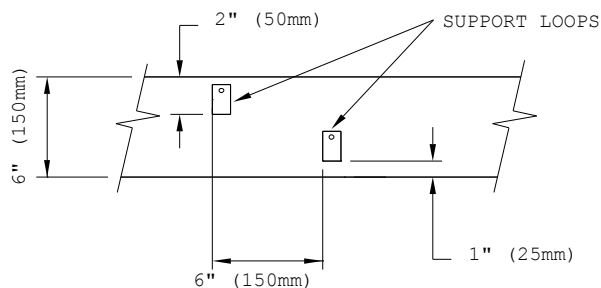
JACKETING FOR HEADS HORIZONTAL AND VERTICAL EQUIPMENT



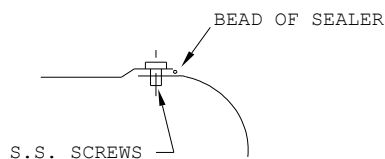
HEAD LAP SEAM



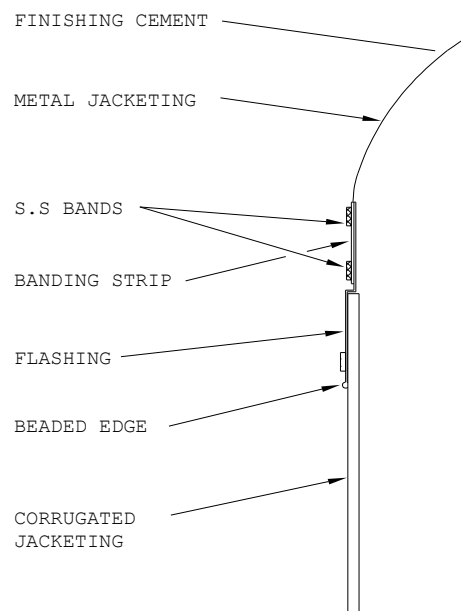
CLOSURE FOR HORIZ. EQUIPMENT HEADS COVER 30" (760mm) DIA.



BANDING STRIP



HORIZONTAL EQUIPMENT HEAD - TO - SHELL JACKETING DETAIL





INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

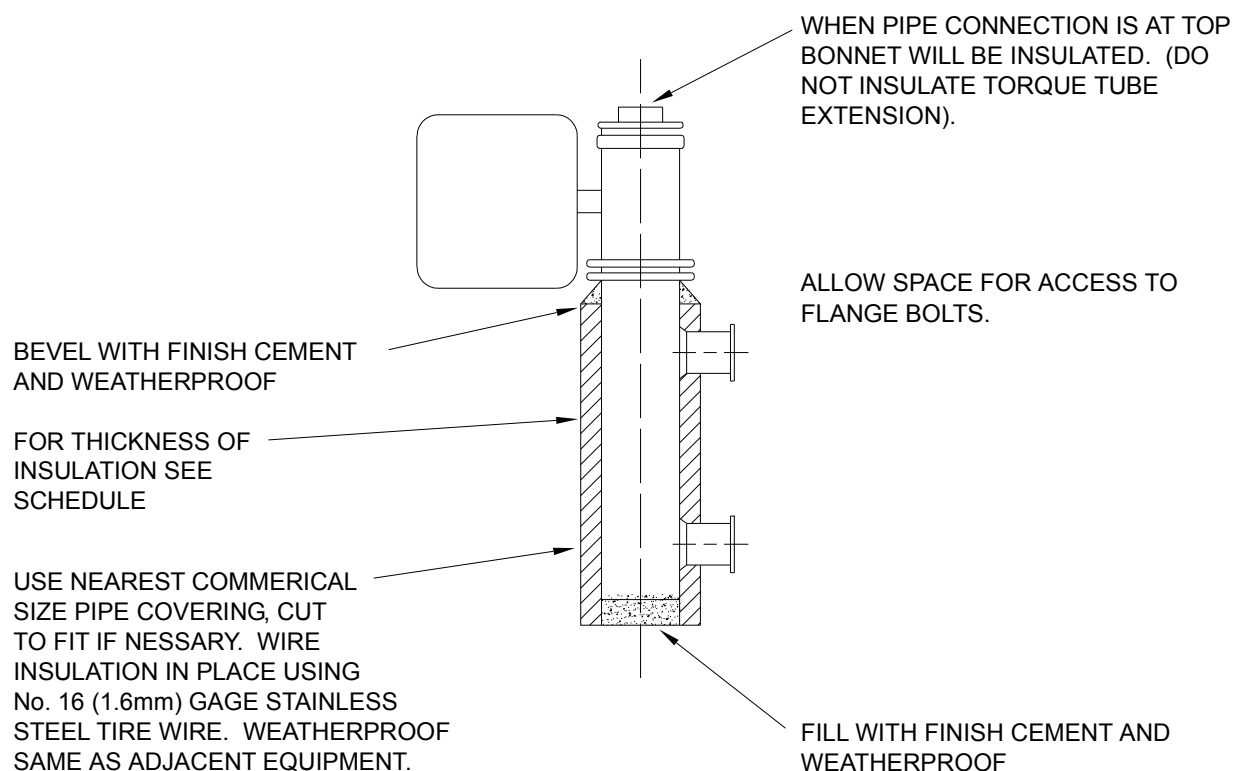
Revision: 4

Date: 21-Feb-11

Page: 46 of 53

ATTACHMENT XIX

INSULATION DETAILS FOR LEVEL CONTROLLERS



NOTES:

1. PIPING BETWEEN LEVEL CONTROLLER AND VESSEL SHALL BE INSULATED (BY PIPING SUBCONTRACTOR).
2. FOR PIPING CONNECTIONS, SEE PIPING DRAWINGS OR APPLICABLE ISOS.
3. ALL JACKETING CORNERS SHALL HAVE PITTSBURGH LOCK SEAMS.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

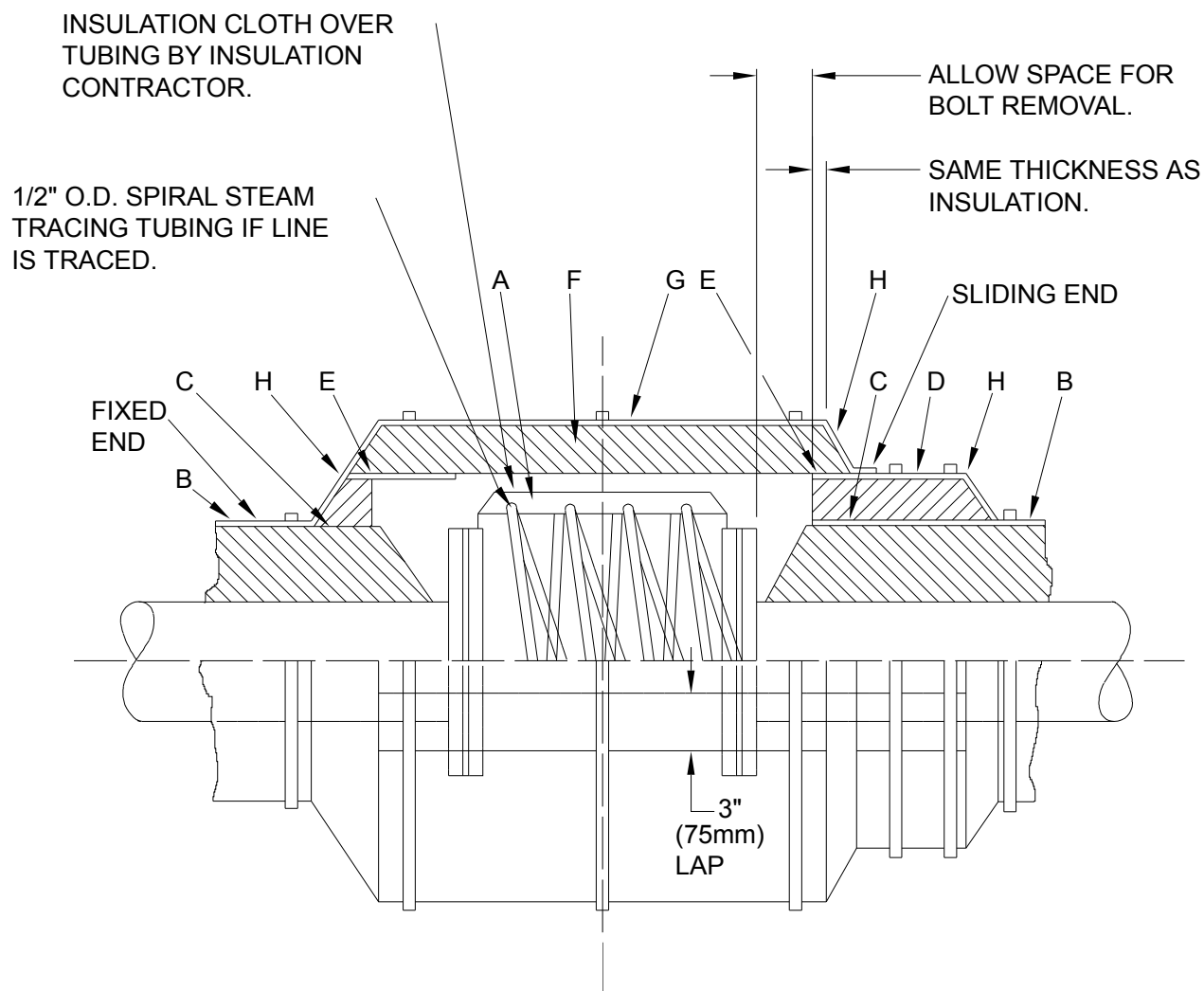
Revision: 4

Date: 21-Feb-11

Page: 47 of 53

ATTACHMENT XX

INSULATION DETAILS - PIPE EXPANSION JOINTS



 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 48 of 53

ATTACHMENT XX

INSULATION DETAILS - PIPE EXPANSION JOINTS
(Continued)

NOTES:

- A. 1/16 in. (1.5 mm) thick insulating cloth shall be wrapped over steam tracing tubing before applying insulation.
- B. Pipe insulation, jacket, bands, etc. shall be same as specified for piping.
- C. Build up pipe insulation to OD of steam tracing plus 1 in. (25 mm). (When expansion joint is not steam traced, build up pipe insulation to OD of the expansion joint plus 1 in. (25 mm). Build up section 4 in. (100 mm) long on fixed end and 12 in. (300 mm) long on sliding end.
- D. Jacket sliding end built up section with 0.020 in. (0.5 mm) thick flat metal jacket with moisture barrier attached. Secure with two 1/2 in. x 0.020 in. (13 mm x 0.5 mm) stainless steel bands and seals, 1 in. (25 mm) and 4 in. (100 mm) from right end of built up section.
- E. Install 0.016 in. (0.4 mm) thick flat metal jacket to extend 3 in. (75 mm) over sliding end. Secure with two, 1/2 in. x 0.020 in. (13 mm x 0.5 mm) stainless steel bands pulled tight over fixed end and intermediate bands on 12 in. (300 mm) center left loose to permit slippage.
- F. Install oversize pipe covering over expansion joint cover. Secure insulation with 1/2 in. x 0.020 in. (13 mm x 0.5 mm) stainless steel bands on 12 in. (300 mm) centers.
- G. Over insulation apply 0.020 in. (0.5 mm) thick flat metal jacket. Secure jacket with 1/2 in. x 0.020 in. (13 mm x 0.5 mm) stainless steel bands and seals spaced 12 in. (300 mm) on centers.
- H. Weatherproof.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

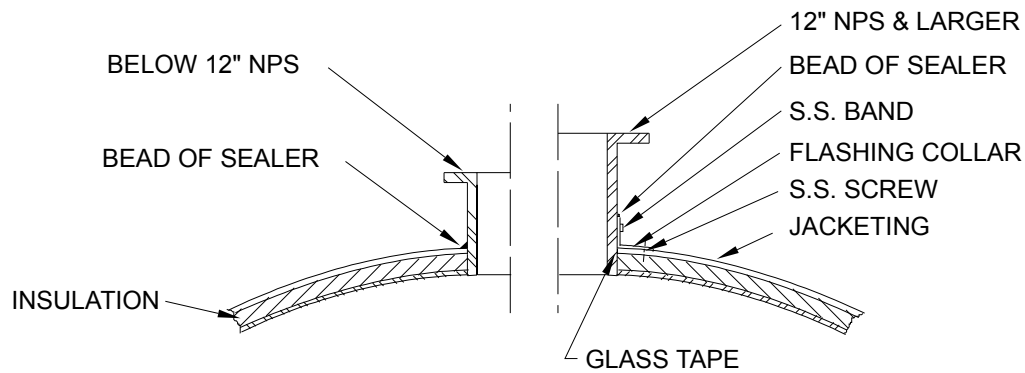
Revision: 4

Date: 21-Feb-11

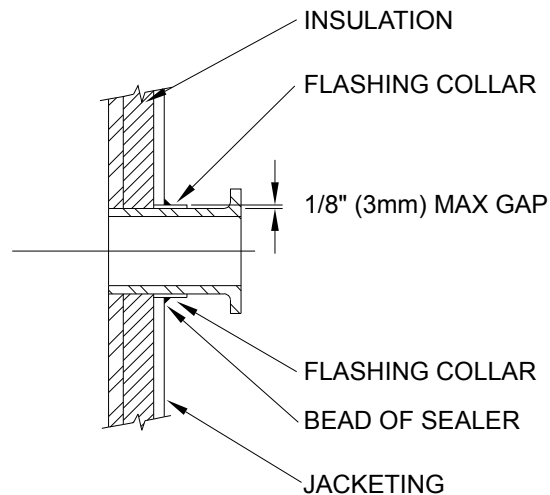
Page: 49 of 53

ATTACHMENT XXI

FLASHING DETAILS FOR UNINSULATED NOZZLES



VERTICAL NOZZLE SEALING

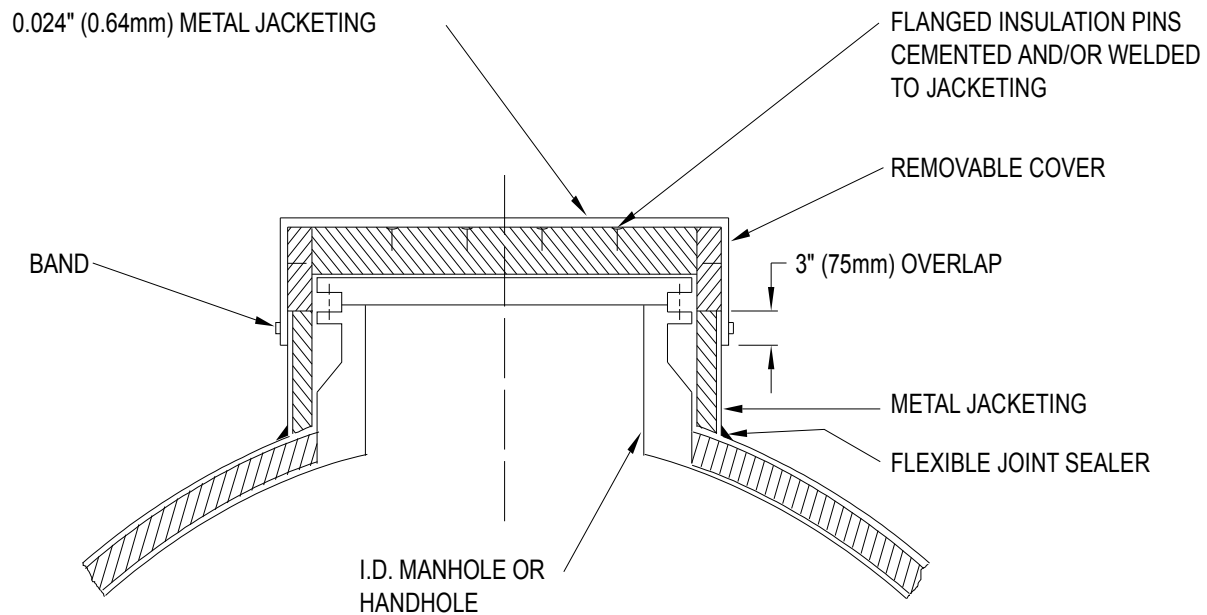


HORIZONTAL NOZZLE SEALING

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
 Refinería de Cartagena S.A.		Revision: 4
		Date: 21-Feb-11
		Page: 50 of 53

ATTACHMENT XXII

INSULATION DETAILS FOR REMOVABLE MANHOLE AND HANDHOLE COVER



NOTE:

1. THE JACKETING SHALL BE CUT TO FIT AROUND DAVIT

	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 51 of 53

APPENDIX A

INSULATION REQUIREMENTS FOR MODULE WORK

1.0 GENERAL

- 1.1 Insulation material for hot service on piping and equipment is specified as mineral wool in the project specification. Due to modules ocean voyage, there is a concern over mineral wool insulation getting wet. The wet insulation will cause in loss of thermal efficiency and can lead to premature corrosion. For the module work Alternate hydrophobic materials, such Expanded Perlite will stay dry even if they come in contact with water.
- 1.2 Shipping braces installed on insulated pipe or equipment shall require removal of insulation at the bracing points. Insulation termination on the both sides of bracing shall be sealed to protect the ingress of water.

2.0 MATERIALS

All insulation materials, metal jacketing and accessories, except as specified below, shall be per the main body and Attachments of this specification.

2.1 Expanded Perlite

- 2.1.1 Preformed expanded perlite insulation shall be used for piping and equipment in Heat Conservation (H) and Personnel Protection (P) in lieu of mineral wool.
- 2.1.2 The expanded perlite shall meet the following requirements:
- 2.1.3 Block and pipe covering shall be suitable for a temperature of 649°C (1200°F), and confirming to ASTM C610.
- 2.1.4 Minimum density shall be 192 kg/m³ (12 lb/ft³).
- 2.1.5 Sectional (two-piece or quads) pipe covering shall be used for all commercially available sizes.
- 2.1.6 All other pipe sizes and for all equipments, insulation shall be curved radius or scored blocks. Width of block shall not be less than 150 mm (six inches).
- 2.1.7 The following manufacturers are acceptable:

Industrial Insulation Group, LLC	Sproule WR-1200
Howred Corp.	Goodtemp

2.2 Metal Jacketing

- 2.2.1 Pipe and equipment insulated using expanded perlite shall have clear acrylic coated aluminum jacketing to prevent staining of metal.
- 2.2.2 The jacketing thickness, polysulyn moisture barrier and surface profile shall be per the project insulation specification.

2.3 Sealing Membrane

- 2.3.1 Alumaguard LT, made by Polyguard, or approved equal shall be used to seal open terminations of insulation. (This membrane will be removed at site after permanent sealing of insulation).

 	INSULATION MATERIALS AND APPLICATION – HOT SERVICE	Document No.: 166000-000-SP-MU10-0004
		Revision: 4
		Date: 21-Feb-11
		Page: 52 of 53

2.4 Insulation design

- 2.4.1 Expanded perlite thickness for heat conservation and personnel protection shall be per insulation thickness of Table in the Attachment III.
- 2.4.2 All insulation shall be protected from water until metal jacketing is installed and insulation terminations are protected.
- 2.4.3 All flanged connections on piping and equipment shall not be insulated in the module yard.
- 2.4.4 Insulation terminations for hot insulation shall be sealed per the figure 1. This detail applies to where the pipe insulation is terminated at the end of module or interrupted for installation of shipping brace or a stiffener.
- 2.4.5 The membrane shall extend over the adjoining metal jacketing for a distance of 75 mm (3 inches) minimum. The membrane shall also extend onto un-insulated projections a minimum of 75 mm (3.0 inches).
- 2.4.6 Metal jacketing for module yard horizontal and vertical piping up to 6" OD of insulation shall have minimum 2 in. (50 mm) circumferential and longitudinal laps.
- 2.4.7 Metal jacketing for module yard horizontal and vertical piping over 6" OD of insulation shall have minimum 3 in. (75 mm) circumferential and longitudinal laps.
- 2.4.8 The longitudinal laps on horizontal piping shall be alternated between four o'clock and eight o'clock position to shed rain water.
- 2.4.9 Manway opening and pipe nozzles on equipment shall have a tight fitting flashing collar and jacketing shall be sealed with heavy fillet of caulking compound.
- 2.4.10 All insulation installation shall be per the main body and Attachments of this specification except additional requirement as stated above.



INSULATION MATERIALS AND APPLICATION – HOT SERVICE

Document No.:

166000-000-SP-MU10-0004

Revision: 4

Date: 21-Feb-11

Page: 53 of 53

FIGURE 1

Insulation Terminations

