PETROBRAS

N-250	REV. J	ENGLISH	05 / 2017

INSTALLATION OF HIGH TEMPERATURE THERMAL INSULATION

Procedure

This Standard replaces and cancels its previous revision.

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the sections, subsections and enumerates thereof.

Technical Requirement: A provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by imperative nature.

Recommended Practice: A provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by verbs of a non-mandatory nature. It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the section, subsection and enumerate to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

CONTEC
Comissão de Normalização Técnica

SC - 09
Thermal Insulation and Refractory

Introduction

PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting of specialists from PETROBRAS and its Subsidiaries), are commented by PETROBRAS Units and PETROBRAS Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of specialists from the same specialty, representing the various PETROBRAS Units and PETROBRAS Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the PETROBRAS Units and PETROBRAS Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS standard N-1. For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.

FOREWORD

This Standard is the English version (issued in February /2021) of PETROBRAS standard N-250 REV. J MAY/2017. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

1 Scope

1.1 This Standard establishes the conditions required for the installation of external thermal insulation for piping, pressure vessels, heat exchangers, boilers, storage tanks, pumps and turbines operating at high temperatures, using rigid or flexible thermal insulation materials.

1.2 This Standard is applied to designs started as of its date of issuance as well as to maintenance or remodeling work on existing facilities/equipment.

1.3 This Standard contains Technical Requirements and Recommended Practices.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

PETROBRAS N-2 - Revestimento Anticorrosivo de Equipamento Industrial;

PETROBRAS N-133 - Soldagem;

PETROBRAS N-442 - Revestimento Externo de Tubulação em Instalações Terrestres;

PETROBRAS N-550 - Projeto de Isolamento Térmico a Alta Temperatura;

PETROBRAS N-1618 - Material para Isolamento Térmico;

PETROBRAS N-2913 - Revestimento Anticorrosivo para Tanque, Esfera e Cilindro de Armazenamento;

ASTM C1696 - Standard Guide for Industrial Thermal Insulation Systems;

ASME BPVC Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Welding and Brazing Qualifications.

3 Terms and Definitions

For the purposes of this Standard, the definitions indicated in PETROBRAS standards N-550 and N-1618 are adopted.

4 General Conditions

4.1 All materials to be used shall comply with PETROBRAS N-1618 and shall be selected and dimensioned according to PETROBRAS N-550.

4.2 Materials Storage

4.2.1 The storage of materials for a long period or in large quantities shall be carried out in temporary, permanent warehouses or in appropriate containers. Advanced storage of materials in the field shall be limited to short-term consumption.

4.2.2 Insulating materials and accessories must not be stored directly on the floor.

4.2.3 The storage of insulating materials, accessories and others (sealants, adhesives, putties, etc.) shall comply with the manufacturer's prescriptions.

4.2.4 If water infiltrates in hygroscopic materials or without waterproofing treatment, the materials shall be discarded. For non-hygroscopic materials or those with waterproofing treatment, drying is allowed, as long as the material is not damaged or loses its characteristics during the process.

4.3 It is recommended that the installation or disassembly of the thermal insulation be carried out when the piping or equipment is not heated. When high temperature assembly or disassembly is required, applicable safety precautions must be taken. **[Recommended Practice]**

4.4 The assembly shall not be carried out directly in the rain, except when the place is dry and protected against bad weather.

4.5 Thermal insulation shall not be installed on wet surfaces, with the presence of loose rust, oily residues, greases and other foreign materials.

4.6 The installation of protective coatings shall be carried out immediately after the assembly of the insulating materials, on the same working journey, unless the assembled insulating materials are protected against the weather. In addition, when there is the possibility of water infiltration during the work shift, provision shall be made for covering the thermal insulation in stretches without the definitive protective coating.

4.7 Insulating materials that are soaked with water during assembly, before or after the installation of the final protective coating, must be replaced. Non-hygroscopic insulating materials or with waterproofing treatments may not require replacement if complete air drying is allowed before the installation of the final protective coating, and if there is no physical degradation of the material.

4.8 The assembly of the thermal insulation must not be started until the completion of the following activities:

a) hydrostatic or pneumatic pressure test of the equipment or piping;

NOTE 1 When requested by PETROBRAS, the assembly of the thermal insulation can be carried out, provided that all welds, flanges and threaded connections are left exposed until the end of the tests and inspection. The ends of the exposed sections of the thermal insulation must be protected to prevent water infiltration.

NOTE 2 It is recommended that the practice of mounting thermal insulation before the completion of the hydrostatic or pneumatic test is avoided, as it increases the chance of damage to thermal insulation and rework during the assembly phase. [Recommended Practice]

b) application of anti-corrosion coating to protect the pipe or equipment, waiting for touch drying for application; and

c) installation and testing of heating traces.

4.9 The use of broken or damaged rigid insulators is not permitted. However, damaged ends can be cut across, eliminating existing damage.

4.10 All welds of devices used for securing insulating material shall be performed in accordance with PETROBRAS standard N-133 and the construction and assembly standards of the facilities/equipment.

NOTE 1 Anchor pins for flexible materials may be welded by the stud welding process and the procedures for welding and welders shall be qualified as per ASME BPVC Section IX.

NOTE 2 For repairs of operative equipments isolation, the anchorage pins for flexible materials may be cold welded, using an epoxy resin compatible to the operation temperature of the equipment.

4.11 The surfaces to be insulated that need corrosion protective coatings, shall be prepared and primer shall be applied in accordance with the following standards:

a) PETROBRAS standard N-2 for equipment;
b) PETROBRAS standard N-442 for piping;
c) PETROBRAS standard N-2913 for tanks.

4.12 The format of the thermal insulators shall be selected according to Table 1.

TABLE 1 - FORM OF THERMAL INSULATION MATERIAL

External Diameter of Equipment mm (in)	Rigid Material	Flexible Material
Ø < 100 (4)	Half Pipe	Pipe or Blanket
100 (4) < Ø ≤ 200 (8)	Half Pipe	Half Pipes,Thin Sheets of Felt or Blanket
200 (8) < Ø ≤ 350 (14)	Segment or Quadrant	Half Pipes,Thin Sheets of Felt or Blanket
350 (14) < Ø ≤ 900 (36)	Segment or Quadrant	Thin Sheets of Felt or Blanket
900 (36) < Ø ≤ 2 500 (100)	Sheet	Thin Sheets of Felt, Board or Blanket
Ø > 2 500 (100)	Sheet	Board or Blanket
NOTE For the outside diameter of equipment, consider the dimensions in mm, while for pipe NPS, consider values in parentheses.		

4.13 Longitudinal and circumferential joints of all layers shall be:

a) rigid materials: joints sealed with insulating cement;
b) flexible materials: compressed so as to ensure a perfect seal.

4.14 Expansion joints must be added whenever a rigid thermal insulator is installed, according to the maximum spacing shown in Table 2. The width of the expansion joints of the rigid thermal insulation shall range between 20 mm and 25 mm (see FIGURE A-14 of ANNEX A). The filler material of the joint shall be made of flexible insulating material.

Table 2 - Maximum Spacing for Expansion Joints

Temperature(°C)	Maximum spacing of expansion joints (m)	
	Ferritic Steel	Austenitic Steel
100	23	14
150	12	8,5
200	8,0	6,0
250	6,0	4,5
300	5,0	3,5
350	4,0	3,0
400	4,0	2,5
500	3,0	2,0

Based on Table 4 from ASTM C1696.

4.15 Longitudinal and circumferential laps of the aluminum protection sheets shall be at least 50 mm, except in the situations indicated in the FIGURES of ANNEX A to this Standard, and arranged in such a manner as to prevent ingress of water. When the longitudinal and circumferential overlays are in a position that water infiltration may occur, the seams shall be sealed with non-drying sealant.

4.16 Bands for securing the insulation and protection sheets shall be held in place by means of seals (see FIGURE A-2 of ANNEX A) so as to ensure a minimum free length of 25 mm.

4.17 When the insulation is made of multiple layers and the operation temperature is higher than 350°C, the securing bands in the inner layer next to equipment or piping (first layer) shall be made of stainless steel.

4.18 In locations with difficult access or high maintenance costs, securing bands and wires shall be made of stainless steel.

4.19 Flanges shall only be thermally insulated when this is specified by the system designer or by the equipment supplier.

4.20 Thermal insulation near flanges shall be interrupted and spaced, in such a manner as to allow the removal of bolts from flanges without causing damages to the insulation.

4.20.1 It is recommended that the minimum distance between the flange and the thermal insulation is equal to 1.2 times the length of the screw, and should not be less than 130 mm, or adjusted according to field needs (for example, for coupling torquing accessories).
[Recommended Practice]

4.20.2 If the exposed section between the flange and the insulation is greater than 300 mm, a removable insulation shall be installed.

4.20.3 The weatherproofing of the insulation termination shall be made with asphalt finishing compound, for services up to 90 ° C, or with aluminum for services up to 600 ° C.

4.21 The aluminum sheets to protect the thermal insulation of calcium silicate must be of type I (with barrier) or the insulator shall be wrapped with bitumen “kraft” paper.

4.22 Class A aluminum sheets (smooth), when used, shall be properly calendared and crimped on the longitudinal and circumferential edges (see Figure A.6 in Annex A).

4.23 The supports of stairs and platforms and other accessories, in the region where they are joined to the insulation, shall have a finish with silicone-based non-drying elastic sealant to prevent water infiltration. The protection sheet in these regions shall be reinforced with sheets cut around the interferences.

4.24 All screws and rivets shall be sealed with non-drying sealant to prevent water from infiltrating through the hole in the protective coating.

4.25 In regions subject to vibration (incidence of wind, vibration of the equipment itself or isolated piping, external incidence of gases, etc.), the use of a chemical lock is recommended in self-tapping screws or replacement by “pop” rivets. **[Recommended Practice]**

4.26 In horizontal heat exchangers, pipes and accessories, and horizontal pressure vessels, it is recommended to drill Ø 10 mm holes in the protective coating for the drainage of water eventually seeping through. The drainage holes shall be located in the lower generatrix and spaced at most 6 m from each other, from the center of the gap between the supports. It is also recommended the opening of drainage holes at low points of pipelines (eg: transition curves between a horizontal (lower) and a vertical one or an inclined one above). **[Recommended Practice]**

4.27 When the pipes, accessories, valves and equipment are protected by means of a physical barrier, replacing the thermal insulation (exclusive) for personal protection, it is recommended to install perforated metal sheets or plates according to Figure A.20 of Annex A. **[Recommended Practice]**

5 Specific Conditions

5.1 Piping

5.1.1 Assembly of Rigid Insulation for Piping

5.1.1.1 Single-layer insulation shall be applied with circumferential, semi-circumferential and longitudinal joints staggered (see Figure A-1 of Annex A).

5.1.1.2 Multilayer insulation shall be applied with circumferential, semi-circumferential and longitudinal joints staggered not only between themselves, but also in relation to those of the previous layer (see Figure A-1 of Annex A).

5.1.1.3 Each layer of insulating material on piping shall be fastened by means of a galvanized carbon steel wire or band, 50 mm from the ends of each part (see Figure A-1 of Annex A), selected according to the nominal pipe diameter as per Table 3.

Table 2 - Attachment of Layers of Rigid Insulating Material

Nominal Pipe Diameter Ø NPS	Attachment
Ø ≤ 6	Wire - 1.25 mm Ø (BWG 18) or Above (Note 2)
Ø > 6	Band - 12.7 mm (1/2")
NOTE 1 In the case of multiple layers, intermediate layers with an outside diameter of 250 mm or larger and the last layer shall be attached with galvanized carbon steel bands, excluding the cases established in items 4.17 and 4.18. NOTE 2 For rigid and fragile thermal insulators (eg cellular glass, polyurethane and polyisocyanurate), a 12.7 mm band must be used in all diameters to avoid cutting the insulation.	

5.1.1.4 Insulation of piping directly supported by elements with bars or the like shall be interrupted in the support region (see Figure A-5.1 of Annex A).

5.1.1.5 Piping with skids shall be insulated in the support region (see Figure A-5.2 of Annex A).

5.1.1.6 On sections with an inclination equal to or greater than 45° with the horizontal, supporting rings shall be installed as bellow:

a) spaced according to Table 4;
b) above flanged connections, spaced from the flange according to 4.20;
c) above curves and tees when the pipe section above the accident is greater than 4.5 m and there is no support ring installed according to a) in this length;
d) in connections of branches, instruments and pipe supports, when the above pipe length is greater than 4.5 m and there is no support ring installed in accordance with a) in this length; and
e) whenever there is an expansion joint in rigid thermal insulators. The support rings must not be spaced more than the expansion joints.

Table 4 - Support Spacing of Rigid Thermal Insulation

Tube Temperature (°C)	Support Spacing (No. of Gutters)
up to 100	8
101 to 200	5
201 to 260	4
261 to 370	3
371 to 650	2
More than 650	1

5.1.1.7 The rigid thermal insulation for piping with tracing shall include the piping and heating line, according to Figure A-3 of Annex A for nominal diameters up to NPS 8 or Figure A-4 of Annex A for larger diameters. Insulating materials shall not be applied in empty spaces.

5.1.2 Assembly of Flexible Insulation for Piping

5.1.2.1 When the flexible thermal insulator is protected with aluminum foil, the assembly shall be carried out as follows.

a) insulation flexible with half pipes or pipes shall comply with items 5.1.1.1 and 5.1.1.2;
b) insulating materials in one or multiple layers shall be attached by means of two 1.25 mm diameter (BWG 18) galvanized carbon steel wires, each 50 mm from the end of the part, and a third one positioned midway between the 2 wires;
c) the insulation of piping supported directly by supports with bars or the like shall be interrupted in the region of the support (see Figure A-5.1 of Annex A);
d) piping with skids shall be insulated in the support region (see Figure A-5.2 of Annex A);
e) on sections with an inclination equal to or greater than 45° with the horizontal, follow item 5.1.1.6 (Except e);
f) thermal insulation of piping with tracing shall include the piping and tracing line, adopting the suitable diameter.

5.1.2.2 When the flexible thermal insulator is protected with coatings other than aluminum sheets, shall follow the manufacturer's specific recommendations.

5.1.3 Protection of Rigid Insulation for Piping

5.1.3.1 The protection of rigid insulation shall be performed according to Table 5.

Table 5 – Protection of Rigid Thermal Insulation

Protective Covering	Thickness (mm)	Nominal Pipe Diameter NPS
Aluminum Class B Type I (corrugated, with barrier)	0.15	Ø ≤ 12
	0.40	Ø > 12
Aluminum Class A Type II (smooth, without barrier) - Notes 2 and 3	0.50	Ø ≤ 8
	0.80	8 < Ø ≤ 24
	1	Ø > 24
NOTE 1 In regions subject to hail, 0.15 mm thick aluminum sheets should not be used. **[Recommended Practice]** NOTE 2 When using the aluminum sheet class A type II, the rigid insulator shall be involved with the bitumen kraft paper sheet. NOTE 3 The aluminum sheet class A type I (smooth, without barrier) shall be used		

5.1.3.2 The corrugated protection sheets shall be secured with bands, according to Table 6, as follows:

a) place a band 10 mm from the end of each overlapping;
b) install 2 equally spaced bands between those placed on each overlapping.

Table 6 - Bands for Securing Protective Sheets

Band		Nominal Pipe Diameter NPS
Material	Width (mm)	
Aluminum	12.7	Ø ≤ 12
	19	12) < Ø ≤ 24
Stainless Steel	12.7	Ø > 24

5.1.3.3 The longitudinal overlap of the thermal insulation protection sheets in horizontal pipes must be located in the 4 o'clock or 8 o'clock position (see detail of the longitudinal joint of the Figure A.6 in Annex A).

5.1.3.4 The longitudinal overlap of the thermal insulating protection sheets in vertical pipes must be located in a position protected from the prevailing wind.

5.1.3.5 When using class A (smooth) aluminum sheet, the edges must be crimped or folded.

5.1.4 Protection of Flexible Insulation for Piping

5.1.4.1 The protection of flexible insulation shall be performed according to Table 7.

Table 7 – Protection of Flexible Thermal Insulation

Protective Coating	Thickness (mm)	Nominal Pipe Diameter NPS
Type II Class A Aluminum Sheet (smooth, without barrier)	0.50	Ø ≤ 8
	0.80	8 < Ø ≤ 24
	1	Ø > 24
High Density Polyethylene (HDP) Pipe	3	Ø ≤ 4
	4	4 ≤ Ø ≤ 8
Extruded Aluminum	1.2	Ø > 8

5.1.4.2 The smooth aluminum sheets shall be attached to the longitudinal laps by means of self tapping screws 150 mm apart and, on the circumferential laps, staggered 90° for piping which diameter with insulation is up to 200 mm (8”) in nominal diameter and 45° for larger diameters (see Figure A-6 of Annex A).

5.1.4.3 The longitudinal overlap of the thermal insulating protection sheets in horizontal pipes must be located in the 4 o'clock or 8 o'clock position (see detail of the longitudinal joint of the Figure A.6 in Annex A).

5.1.4.4 The longitudinal overlap of the thermal insulation protection sheets in vertical pipes must be located in a position protected from the prevailing wind.

5.1.5 Bends, Tee, Reducers and Plugs

Pipe fittings (bends, tees, reducers and plugs) shall be insulated according to the following procedure described in items 5.1.5.1 and 5.1.5.2:

5.1.5.1 When assembly rigid thermal insulation:

5.1.5.1.1 Cut and apply the same material used on the piping, maintaining the geometric configuration, securing it with a wire or band.

5.1.5.1.2 Apply a 3 mm thick layer of insulating cement;

5.1.5.1.3 To perform the protection of the rigid thermal insulation by means of one of following alternatives:

a) alternative 1 (preferred):
   - assembly the thermal insulation protection with class A (smooth) aluminum plate, - mount the thermal insulation protection with class A (smooth) aluminum plate, calendered in sections or in a bipartite shaped curve;

b) alternative 2 (see Figure A.7 in Annex A):
   - apply a layer of asphalt-based finishing putty;
   - after drying the putty, fix the reinforcement mesh;
   - apply a second layer of asphalt-based finishing putty on the canvas, so that the minimum total thickness is 3 mm when dry, has a smooth finish without cracks and does not present visible contours of the canvas;
   - the asphalt-based finishing putty layer and the screen must extend 50 mm under the protection sheet, which shall be fixed before the second finishing putty layer is dried; and
   - the vertical joints between the protective sheets and the asphalt-based finishing grease, favorable to water infiltration, shall be sealed with non-drying sealant.

5.1.5.2 In case flexible insulation material is applied, the protection shall be provided by means of the smooth aluminum sheet calendered in buds, keeping the accident geometry, fixing the insulating material with wire.

5.1.6 Valves, Flanges and Unions

For insulation of valves, flanges and unions, an analysis shall be made of whether or not it is convenient to apply insulation according to one of options bellow:

a) removable split boxes made from 0.80 mm thick class A smooth aluminum sheets, using flexible insulating material (see FIGURE A-8 of ANNEX A).
b) thermal jackets; or
c) according 5.1.5.

5.1.7 Buried Piping

5.1.7.1 Buried piping shall be insulated only with rigid insulating.

5.1.7.2 The insulation protection sheet should be a class A (smooth), type I (with barrier) aluminum sheet with minimal thickness of 0.80 mm or with conformed polymeric material. **[Recommended Practice]**

5.1.7.3 If chosen protection with a class A (smooth) aluminum plate, the plate shall be waterproofed with polymeric material that prevents the infiltration of water or another alternative system defined in the design.

5.1.7.4 The insulation protection in polymeric material shall have treatment in the unions in order to secure system’s tightness.

5.1.7.5 Waterproofing shall extend, at least, 1 000 mm on each end of the buried region.

5.1.8 Expansion Curve of Steam Trace

5.1.8.1 The expansion curves of the steam trace lines, external to the thermal insulation, shall be insulated with a glass wool or ceramic fiber cord, in two overlapping layers.

5.1.8.2 The joints between the steam trace insulation and the protection sheet of the piping insulation shall be sealed against ingress of water by means of an non-drying sealant.

5.1.8.3 The steam trace line insulation shall be waterproofed.

5.1.9 Thickness Periodic Measurements

On the spots where periodic measurements of piping or equipment thickness are needed, shall be performed openings provided with one of following protections:

a) aluminum box for periodic thickness measurements, according to PETROBRAS N-1618;
b) aluminum frame with silicone plug, in circular or oblong shapes, fixed by rivets, screws or straps. The edges of the frame and all water infiltration points must be sealed with non-drying sealant.

5.2 Pressure Vessels and Heat Exchangers

5.2.1 Shells of Horizontal Pressure Vessels

5.2.1.1 Rigid Thermal Insulation for Horizontal Vessels

a) circumferential joints of insulating parts shall be staggered at least 1/3 of their length and the longitudinal ones (between layers) half their width;
b) horizontal shells shall have near both heads a ring 300 mm from the head-to-shell weld for holding the bands in place (see Figure A-10 of Annex A);
c) the shells of pressure vessels with a perimeter over 6 000 mm and an operating temperature above 150 °C shall have on the bands for supporting the last layer of insulating material and the protection sheet, 1 sinusoidal or helical spring for every 6 000 mm or fraction thereof, so as to compensate for thermal expansions;
d) for diameters of 1 800 mm or smaller, the insulation shall be attached to the shell by means of 12.7 mm wide galvanized carbon steel bands 300 mm apart and covering the entire circumference of the shell;
e) for diameters over 1 800 mm, the insulation shall be attached to the shell by means of 12.7 mm wide galvanized carbon steel bands 300 mm apart and anchored to supports, no more than 6 000 mm from each other (see Figure A-13 of Annex A);
f) for multilayer insulation, the internal layers shall be held in place by means of 12.7 mm wide galvanized carbon steel bands spaced at 300 mm intervals, except in the cases set forth in items 4.14 and 4.18;
g) the region of attachment supports shall be filled with flexible material;
h) the thermal insulation of the equipment's surface shall be protected with 0.40 mm thick class B aluminum sheets (corrugated), which shall overlap 50 mm on longitudinal and circumferential joints; it is accepted the use of 1 mm thick smooth aluminum sheet to the thermal insulation protection;
i) the bands to be used for attaching the protective covering (see Figure A-13 of Annex A) shall be in accordance with Table 6;
j) aluminum sheets shall be attached with bands as follows:
   - place one band 10 mm from the end of each lap;
   - install one band between the ones placed on the laps with a spacing of approximately 430 mm.

5.2.1.2 Flexible Thermal Insulation for Horizontal Vessels

a) flexible materials in the form of blanket, flexible panels or anchoring modules may be used; **[Recommended Practice]**

b) circumferential joints of insulating parts shall be staggered at least 1/3 of their length and the longitudinal ones (between layers) half their width;
c) horizontal shells shall have near both heads a ring 300 mm from the head-to-shell weld for holding the bands in place (see Figure A-10 of Annex A);
d) the shells of pressure vessels with a perimeter over 6 000 mm and an operating temperature above 150 °C shall have on the bands for supporting the last layer of insulating material and the protection sheet, one sinusoidal or helical spring for every 6 000 mm or fraction thereof, so as to compensate for thermal expansions;
e) the fixation of the insulating coating to the equipment's shell shall be done so that there is no condensation of material by equipment vibration the following forms of attachments shall be contemplated:
   - insulating coating in blankets and flexible panels: attach the insulating material to the shell by using anchorage pins with pressure clips in accordance to the detail B of Figure A-18.7; the anchorage distribution shall follow the same indicated on Figure A-18.8; for diameters of less or equal to 1 200 mm: the attachment of the insulation to the shell may be done by means of 12.7 mm width galvanized steel-carbon bands 400 mm spaced, covering all the shell's circumference;
   - insulating coating in anchoring modules: use the attachment system imbedded in the insulating modules;
f) the region of attachment supports shall be filled with flexible insulating material;
g) the thermal insulation of the equipment surface shall be protected class A aluminum sheets (smooth); and
h) the fixing of class A aluminum sheets (smooth) shall be made in longitudinal and circumferential overlays by means of crimps and self-tapping screws, spaced 150 mm apart.

5.2.2 Shells of Vertical Pressure Vessels (Except Coke Drums)

5.2.2.1 Rigid Thermal Insulation for Vertical Vessels

a) circumferential joints of insulating parts shall be staggered at least 1/3 of their length and the longitudinal joints (between layers) half their width;
b) vertical vessels shall have near both heads a ring 300 mm from the head-to-shell weld for holding the head's insulation attachment bands (see Figures A-9 and A-10 of Annex A);

NOTE 1 In the case of vessels with a skirt and without fire protection, the bottom ring shall be placed 300 mm below the head-to-shell attachment weld.
NOTE 2 Vessels with a skirt and with fire protection do not need a ring near the bottom head.

c) the shells of pressure vessels with a perimeter over 6 000 mm and an operating temperature over 150 °C shall have, on the bands supporting the last layer of the insulating material and protection sheet, a spring for every 6 000 mm or fraction thereof so as to compensate for thermal expansions;
d) the thermal insulation shall be supported on supporting rings 4 000 mm apart (see Figures A-9 and A-14 of Annex A);
e) the thermal insulation shall be attached with 12.7 mm wide galvanized carbon steel bands 300 mm apart (see Figure A-14 of Annex A);
f) for multilayer insulation, the internal layers shall be held in place with 12.7 mm wide galvanized carbon steel bands 300 mm apart, except to the cases established in 4.17 and 4.18.
g) for rigid materials, expansion joints shall be installed beneath the supporting rings in accordance with item 4.14;
h) for the shell, the thermal insulation shall be protected with 0.40 mm thick class B (corrugated) aluminum sheets, which shall overlap 50 mm on longitudinal and circumferential joints; it is accepted the use of 1 mm thick aluminum smooth sheet to the thermal insulation protection;
i) protection sheets shall be positioned with the aid of “S” clips no more than 1 000 mm apart, and securing bands shall be positioned with the aid of “J” clips no more than 1 500 mm apart and attached with self tapping screws;

j) the bands to be used in the attachment of aluminum sheets (see FIGURE A-14 of Annex A) shall be according to Table 6;
k) aluminum sheets shall be attached with bands, as follows:
   - attach a band 10 mm from the end of each lap;
   - install 1 band, between those placed on the laps, with a spacing of approximately 430 mm.

5.2.2.2 Flexible Thermal Insulation for Vertical Vessels:

a) flexible materials in the form of blanket, flexible panels or anchoring modules may be used; **[Recommended Practice]**
b) circumferential joints of insulating parts shall be staggered at least 1/3 of their length and the longitudinal joints (between layers) half their width;
c) vertical vessels shall have near both heads a ring 300 mm from the head-to-shell weld for holding the head insulation attachment bands (see FIGURES A-9 and A-10 of Annex A);

NOTA 1 In the case of vessels with a skirt and without fire protection, the bottom ring shall be placed 300 mm below the head-to-shell attachment weld.
NOTA 2 Vessels with a skirt and with fire protection do not need a ring near the bottom head.

d) the shells of pressure vessels with a perimeter over 6 000 mm and an operating temperature over 150 °C shall have, on the bands supporting the last layer of the insulating material and protection sheet, a spring for every 6 000 mm or fraction thereof so as to compensate for thermal expansions;
e) the attachment of the insulating coating to the equipment's shell shall be done so that there is no condensation of material by equipment vibration. The following forms of attachments shall be contemplated:
   - insulating coating in blankets and flexible panels: attach the insulating material to the shell by using anchorage pins with pressure clips in accordance to the detail B of Figure A-18.7; the anchorage distribution shall follow the same indicated on Figure A-18.8; for diameters of less or equal to 1 200 mm: the attachment of the insulating to the shell may be done by means of 12.7 mm width galvanized steel-carbon bands 400 mm spaced, covering all the hull circumference; in this case, the thermal insulation shall be supported in 3 050 mm spaced supporting rings (see Figures A-9 and A-10 of Annex A);
   - insulating coating in anchoring modules: use the attachment system imbedded in the insulating modules;
f) for multilayer insulation, the internal layers do not need complementary attachment by bands;
g) the region of attachment supports shall be filled with flexible material;
h) the thermal insulation of the equipment’s shell shall be protected with class A aluminum sheets (smooth) of 1 mm thick; and
i) the fixing of the class A aluminum sheets (smooth) shall be performed in the longitudinal and circumferential overlays by means of crimps and self-tapping screws, spaced 150 mm apart.bands and 150 mm spaced.

5.2.3 Coke Reactor

5.2.3.1 Rigid Thermal Insulation for Coke Reactors

a) the insulation of the coke reactor shall be in accordance with item 5.2.2.1; (assembly of rigid thermal insulation on the shell of vertical pressure vessels);
b) the anchorage system of the insulation shall be in accordance with Figure A-15.1 of Annex A;
c) the dilatation joints along the shell shall be in accordance with Figure A-15.2 of Annex A;
d) the spacing of anchorage to the thermal insulation attachment shall be in accordance with Figure A-15.3 of Annex A; and

e) the isolation of the top of the reactor can be carried out in a thermal jacket, made with reinforced and waterproofed fabric compatible with the temperature of equipment, to allow the insulation to accompany the expansion of the worktop. **[Recommended Practice]**

5.2.3.2 Flexible Thermal Insulation for Coke Reactors

a) the insulation of the coke reactor shall be in accordance with item 5.2.2.2 (assembly of flexible thermal insulation on the shell of vertical pressure vessels);
b) alternately, the anchorage system of the insulation may be of the floating type (not directly attached to the shell), as per Figures A-15.4 and A-15.5, with protection on 0.8 aluminum undulated sheet;
c) the insulation of reactor's rounded may be done by isolating jacket, manufactured with reinforced and waterproof fabric compatible to the equipment work heat, to allow the insulation to follow the equipment dilatation; **[Recommended Practice]**
d) the insulation of reactor conic stretch shall be made by anchoring modules of flexible insulating material.

5.2.4 Pressure Vessel Heads

5.2.4.1 Thermal insulation shall be performed by conforming the insulation material so that it is perfectly seated on the surface.

5.2.4.2 The thermal insulation material shall be attached by means of 12.7 mm wide galvanized carbon steel bands spaced no more than 300 mm apart.

5.2.4.3 The bands shall be attached (see Figure A-10 of Annex A) by means of a bar type floating ring 1/2" in diameter, placed on top of the head and a supporting ring attached to the shell, according to items 5.2.1.1 paragraph b) and 5.2.1.2 paragraph c).

5.2.4.4 Alternatively, in vertical vessels with a skirt, the insulating material of the bottom head shall be attached by means of a 1.25 mm diameter (BWG 18) galvanized carbon steel wire anchored in "G" clamps or carbon steel hex nuts with a triangular spacing of 300 mm on the side, welded to the head (see Figure A-11 of Annex A).

5.2.4.5 In case of application of rigid insulation material, the protection shall be made according with one of the following alternatives:

a) by 1 mm thick class A aluminum (smooth) sheet, sealed with non-drying sealant (preferred alternative);
b) by insulating jacket, manufactured with reinforced and waterproof fabric to allow the insulation to follow the equipment dilatation; or
c) by asphalt mass as per item 5.1.5.1.2 paragraph and 5.1.5.1.3 (alternative 2), with 5 mm of minimal total thickness of dry asphalt mass and 150 mm extended over the protection sheet (see Figure A-10 of Annex A).

5.2.4.6 In case of the application of flexible insulating material, the protection shall be made according with one of the following alternatives:

a) by 1 mm thick aluminum smooth sheet, sealed with non-drying sealant;
b) by insulating jacket, manufactured with reinforced and waterproof fabric to allow the insulation to follow the equipment dilatation.

5.2.5 Heat Exchanges (Shell and Tube Types)

5.2.5.1 The thermal insulation of heat exchanges shall be performed according to the procedures established in 5.2.1 (assembly of thermal insulation in vertical pressure vessels).

5.2.5.2 The thermal insulation located near to shell flanges, spool and fillet shall be removable, as shown in Figure A.16 of Annex A.

5.2.5.3 The thermal insulation of the heat exchanger fillets must be carried out as follows:

a) when the fillet is flanged:
- by means of removable boxes of class A aluminum sheets (smooth), with a thickness of 1 mm, using flexible insulating material, according to Figure A.16 of Annex A;

or

- with thermal jackets;

b) when the fillet is welded: according to 5.2.4 (pressure vessel tops).

5.2.6 Reinforcement Rings

5.2.6.1 The various types of reinforcement rings shall be insulated as illustrated in Figure A-12 of Annex A.

5.2.6.2 The thermal insulation shall be protected in accordance with item 5.2.4.5 paragraph a) and c), with the extension under the protection sheet being 75 mm.

5.2.6.3 In the spots where thickness periodical measurements are needed, it is recommended to be left openings provided with boxes for periodical measurement. **[Recommended Practice]**

5.2.6.4 Nameplates, stamped characters and inspection code plates shall not be insulated, but the ends of the thermal insulation materials near those accessories shall be sealed with silicone-based non-drying elastic sealant.

5.3 Storage Tanks

In regions subject to strong winds, a high rainfall rate or an operating temperature of 100 °C or above, alternative 2 shall be used. For the other conditions, an economic study shall be carried out for the selection of the best alternative.

5.3.1 Shell of Storage Tanks- Alternative 1

5.3.1.1 Rigid insulating materials shall be used.

5.3.1.2 A supporting plate shall be attached on the entire circumference of the shell at a height of 500 mm from the tank bottom. The supporting plates are comprised of segments 2 000 mm to 3 000 mm long with 100 mm intervals between segments and a width equal to the thickness of the insulation (see Figure A-17.1 of Annex A).

5.3.1.3 The attachment supports shall be comprised of 12.7 mm (1/2") carbon steel bars vertically arranged on the shell, spaced up to 6 000 mm apart and attached by welds at every 1 800 mm (see FIGURES A-17.1, A-17.2, A-16.3 and A-17.6 of Annex A).

5.3.1.4 The supporting bars shall be made of 38 mm x 3.2 mm (1 1/2" x 1/8") galvanized carbon steel plates welded to attachment supports (bars) (see FIGURE A-17.1, A-17.2 and A-17.6 of Annex A).

5.3.1.5 The plates and bars shall be previously painted and touched up after welding in those cases in which the shell also has to be painted.

5.3.1.6 Before the first layer begins to be installed, the peripheral ring of the tank bottom shall receive a layer of asphalt base waterproofing material 6 mm in thickness, when dry.

5.3.1.7 After the first ring of insulating material is placed, the external surface of the ring shall receive a layer of asphalt base waterproofing material 6 mm in thickness, when dry, at a minimum height of 200 mm (see FIGURES A-17.1 and A-17.2 of ANNEX A).

5.3.1.8 The circumferential joints of insulating parts shall be staggered at least 1/3 of their length and the longitudinal ones (between layers) half their width.

5.3.1.9 The insulation shall be secured with 12.7 mm (1/2") wide galvanized carbon steel or stainless steel bands, attached to the bars by means of seals, with a free band length of 100 mm being left to allow for expansion.

5.3.1.10 The spacing between bands used for securing the insulation shall be 300 mm, with the first band being placed 250 mm from the supporting plate or from the bottom plate (see FIGURES A-17.1 and A-17.2 of Annex A).

5.3.1.11 Insulation protection shall be provided by means of class A (smooth sheet) or class B (corrugated sheet) 0.80 mm thick aluminum sheets, with an overlapping of 50 mm on longitudinal and circumferential joints (see Figure A-17.4 of Annex A).

5.3.1.12 The protection sheets mentioned in item 5.3.1.11 shall be secured to the supporting bars by means of slotted hex head self tapping screws, with washers, and spaced 150 mm apart, at every circumferential joint. On the other joints, the sheets shall be attached by screws 150 mm apart (see Figures A-17.1, A-17.2 and A-17.4 of Annex A).

5.3.1.13 Protection sheets shall be positioned with the aid of "S" clips 1 000 mm apart and attached with screws (see Figures A-17.1, A-17.2 and A-17.4 of Annex A).

5.3.2 Shell of Storage Tanks - Alternative 2

5.3.2.1 Flexible thermal insulating materials shall be used.

5.3.2.2 A 38 mm x 4.8 mm (1 1/2" x 3/16") section carbon steel supporting bar shall be welded on the entire circumference of the shell at a height of 500 mm from the tank bottom. This supporting bar shall be comprised of 2 700 mm to 3 600 mm long segments, at 100 mm intervals and the distance from the shell shall be equivalent to the thickness of the insulating material (see Figures A-18.1, A-18.7 and A-18.8 of Annex A).

5.3.2.3 A 38 mm x 4.8 mm (1 1/2" x 3/16") carbon steel supporting bars shall be welded on the entire circumference of the shell, spaced 1 470 mm apart in the longitudinal direction and comprised of segments according to item 5.3.2.2. The intervals shall be staggered in relation to the bars immediately above and below at least 1/3 of their length (see Figures A-18.1, A-18.2 and A-18.7 of Annex A).

5.3.2.4 The supports of the supporting bars mentioned in items 5.3.2.2 and 5.3.2.3 shall be aligned and welded in the longitudinal direction, with a spacing of 900 mm to 1 200 mm in the circumferential direction of the shell (see FIGURES A-18.1 and A-18.7 of Annex A).

5.3.2.5 Anchor pins shall be aligned and welded at every 300 mm in the longitudinal direction and at every 300 mm in the circumferential direction of the shell (see Figures A-18.7, A-18.8 and A-18.10 of Annex A).

NOTE The external painting of the tank, if necessary, shall be performed after the anchor pins have been welded.

5.3.2.6 Before the insulation material begins to be installed, the peripheral ring of the tank bottom shall receive a layer of asphalt base waterproofing material 6 mm thick, when dry (see FIGURE A-18.8 of Annex A).

5.3.2.7 The insulating material shall be protected by means of trapezoidal aluminum tiles with a circumferential overlapping of 200 mm and a longitudinal overlapping of 65 mm (see FIGURE A-18.2 of ANNEX A).

5.3.2.8 The protection sheets mentioned in item 5.3.2.7 shall be attached to the supporting bar by means of slotted hex head self-tapping screws spaced 330 mm apart on circumferential laps. On longitudinal laps, the sheets shall be attached together by slotted pan head self tapping screws spaced 290 mm apart or alternatively with double-sided self adhesive PVC tape (see Figures A-18.2 and A-18.3 of Annex A).

5.3.2.9 As protection for the insulating material near the intersection of the shell and the roof, an aluminum cap receiver (see Figures A-18.4 and A-18.9 of Annex A) shall be used.

5.3.2.10 The space available between the aluminum cap receiver and the sheet or angle of the roof shall be sealed with silicone-base non-drying elastic sealant (see Figure A-18.4 of Annex A).

5.3.2.11 At intersections between supports of stairways, platforms and other accessories and the thermal insulation of the shell, non-drying elastic sealant shall be applied to prevent water infiltration. These regions shall be reinforced with 0.8 mm thick smooth aluminum sheets cut and riveted according to the geometric configuration (see Figure A-18.5 of Annex A).

5.3.2.12 Boxes for periodic thickness measurements shall be installed on the shell along the stairs (see Figure A-18.6 of Annex A).

5.3.3 Roof of Storage Tanks

5.3.3.1 Rigid thermal insulation materials shall be used.

5.3.3.2 Attachment supports shall be made with 12.7 mm (1/2”) carbon steel bars arranged in parallel over the roof, spaced 3 000 mm apart and attached by welds at every 1 500 mm (see Figure A-19 of Annex A).

5.3.3.3 The insulation shall be attached with 12.7 mm (1/2”) wide galvanized carbon steel band spaced 450 mm apart (see Figure A-19 of Annex A).

5.3.3.4 The bars shall be previously painted and touched up after welding in those cases in which the roof also has to be painted.

5.3.3.5 The insulation material shall be protected according to the following procedure:

a) apply on the insulating material a 3 mm thick (wet) layer of asphalt-base waterproofing material;
b) apply a layer of asphalt felt with an overlapping of 50 mm;
c) apply a second layer of asphalt-base waterproofing material 3 mm thick (wet);
d) apply a second layer of asphalt felt with an overlapping of 50 mm and staggered 60° in relation to the previous layer;
e) apply a third layer of asphalt base waterproofing material 3 mm thick (wet);
f) apply a third layer of asphalt felt with an overlapping of 50 mm and staggered 60° in relation to the previous layer;
g) apply a 5 mm thick (dry) layer of hot oxidized asphalt;
h) apply uniformly a layer of crushed stones on the entire surface of the roof, on the oxidized asphalt while still pasty.

5.4 Pumps and Turbines

5.4.1 Removable Thermal Insulation for Pumps and Turbines

Pumps and turbines shall be insulated in accordance with the original design or, in the absence thereof, according to the following criteria:

a) by means of 0.80 mm thick removable boxes of class A (smooth sheet) aluminum sheets, using flexible material (see Figure A.8.2 of ANNEX A);
b) by means of flakes of glass wool, ceramic wool or rock wool packed in thermal bags; or
c) by means of insulating jackets, using flexible insulating material.

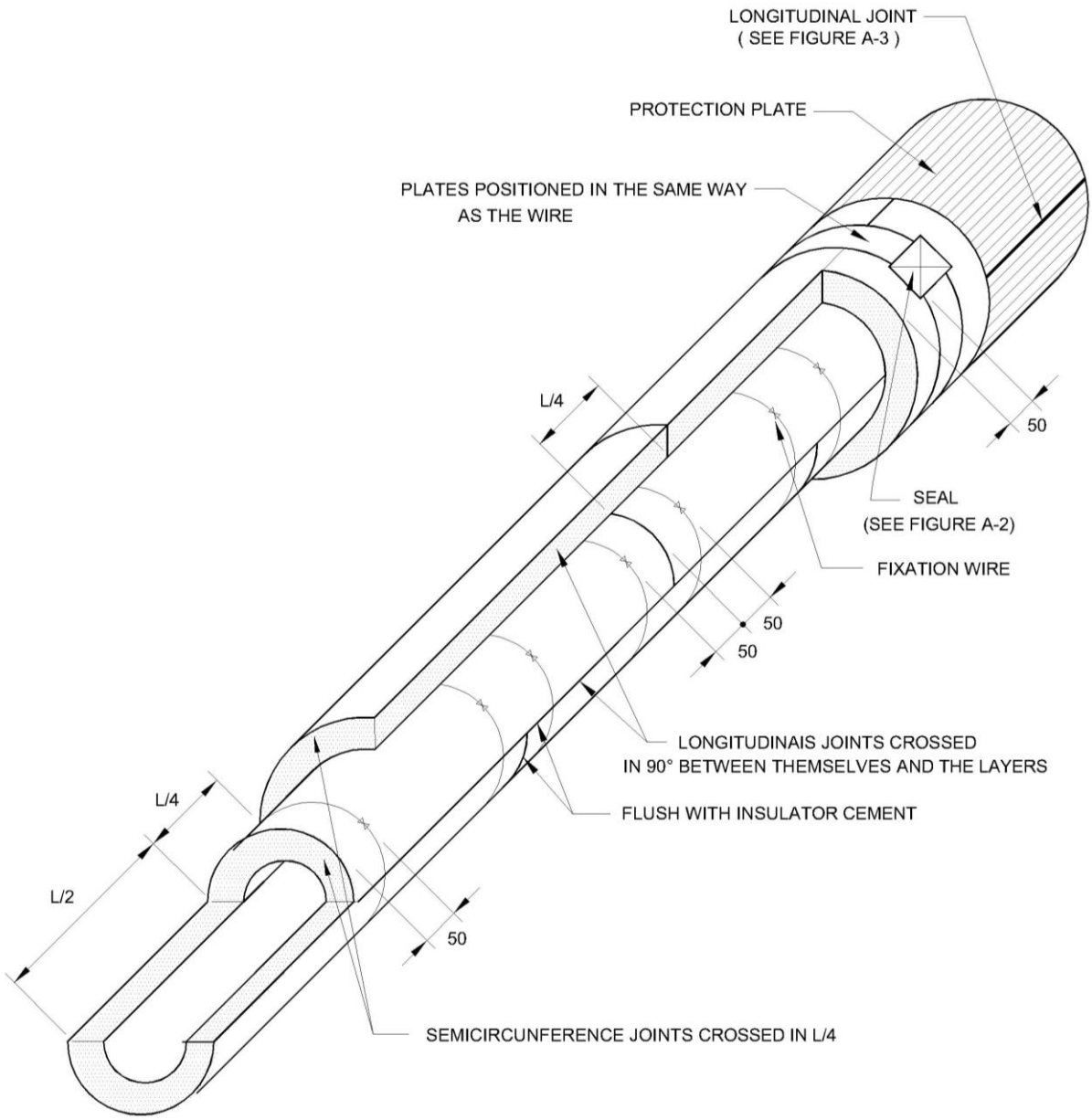
5.4.2 Fixed Thermal Insulation for Pumps and Turbines

The insulating material shall be molded to the surface of the equipment so that the thickness of the insulation at any point is equal to or greater than that specified in the design, in accordance with item 5.1.5.1.2 and 5.1.5.1.3 (Alternative 2).

5.5 Boilers

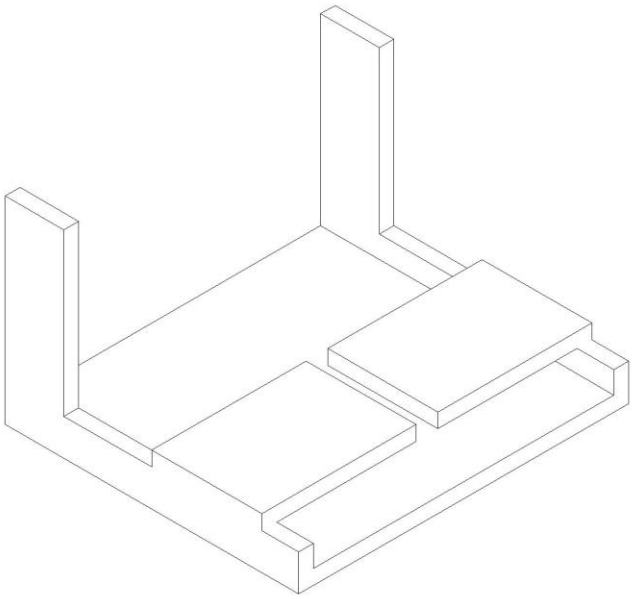
Flexible insulators installed as per manufacturer’s original design shall be used.

ANNEX A - FIGURES

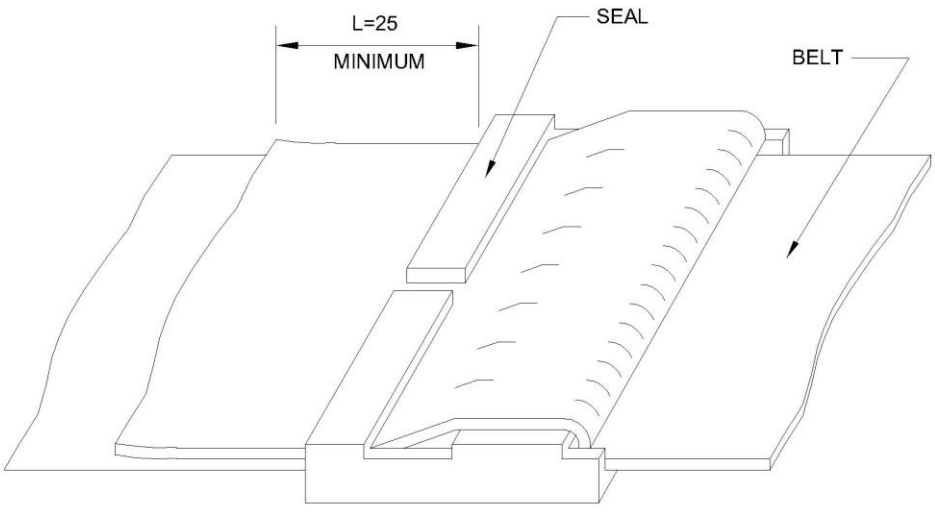


NOTES: 1) IN THE CASE OF SEGMENTS, THE LONGITUDINAIS JOINTS SHALL BE CROSSED IN HALF OF THE WIDTH.
2) L = WIDTH OF CHANNEL OR SEGMENT.
3) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-1 - Arrangement of Joints for Rigid Thermal Insulation of Piping



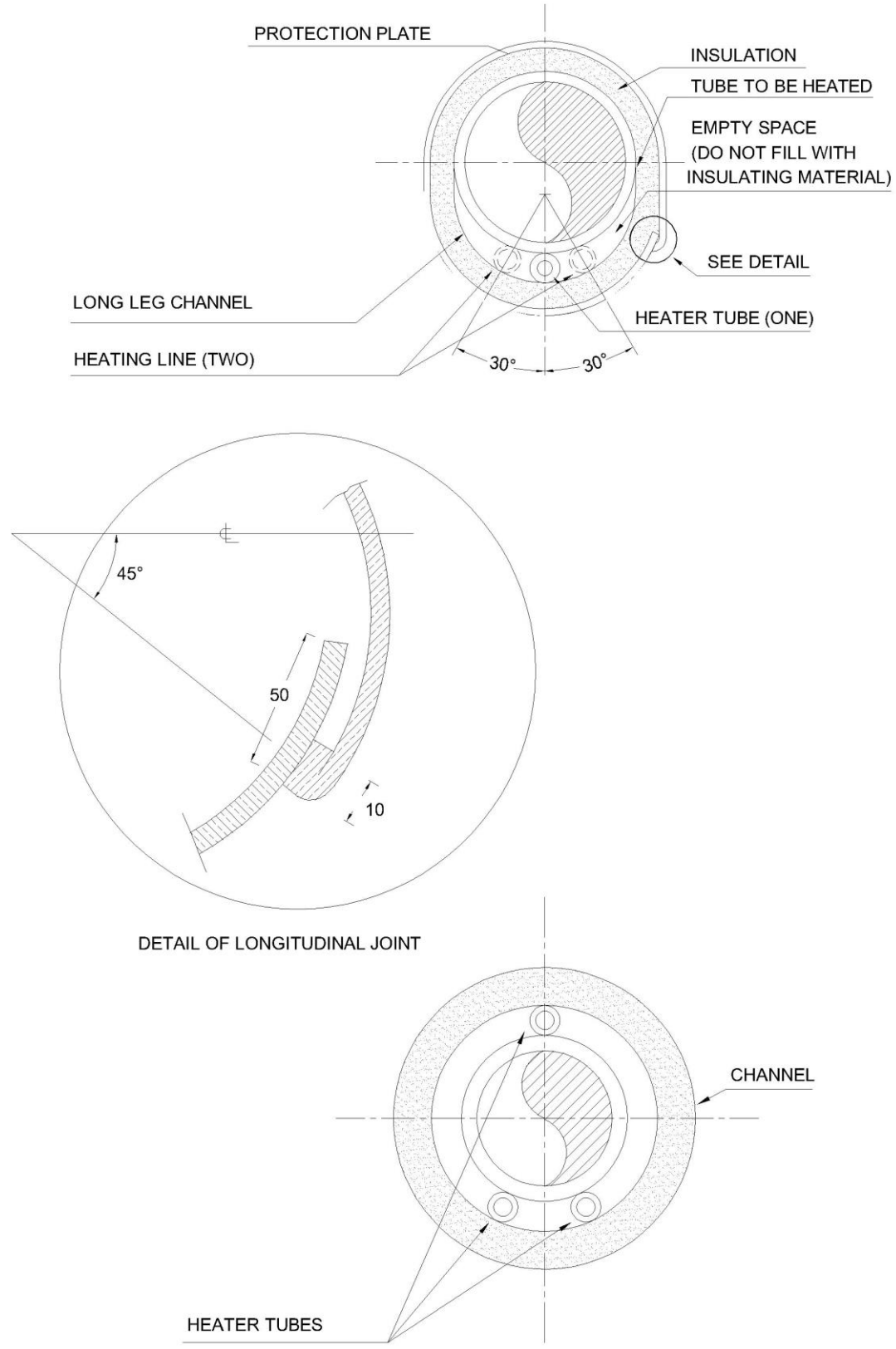
SEAL BEFORE APPLICATION



APPLIED SEAL

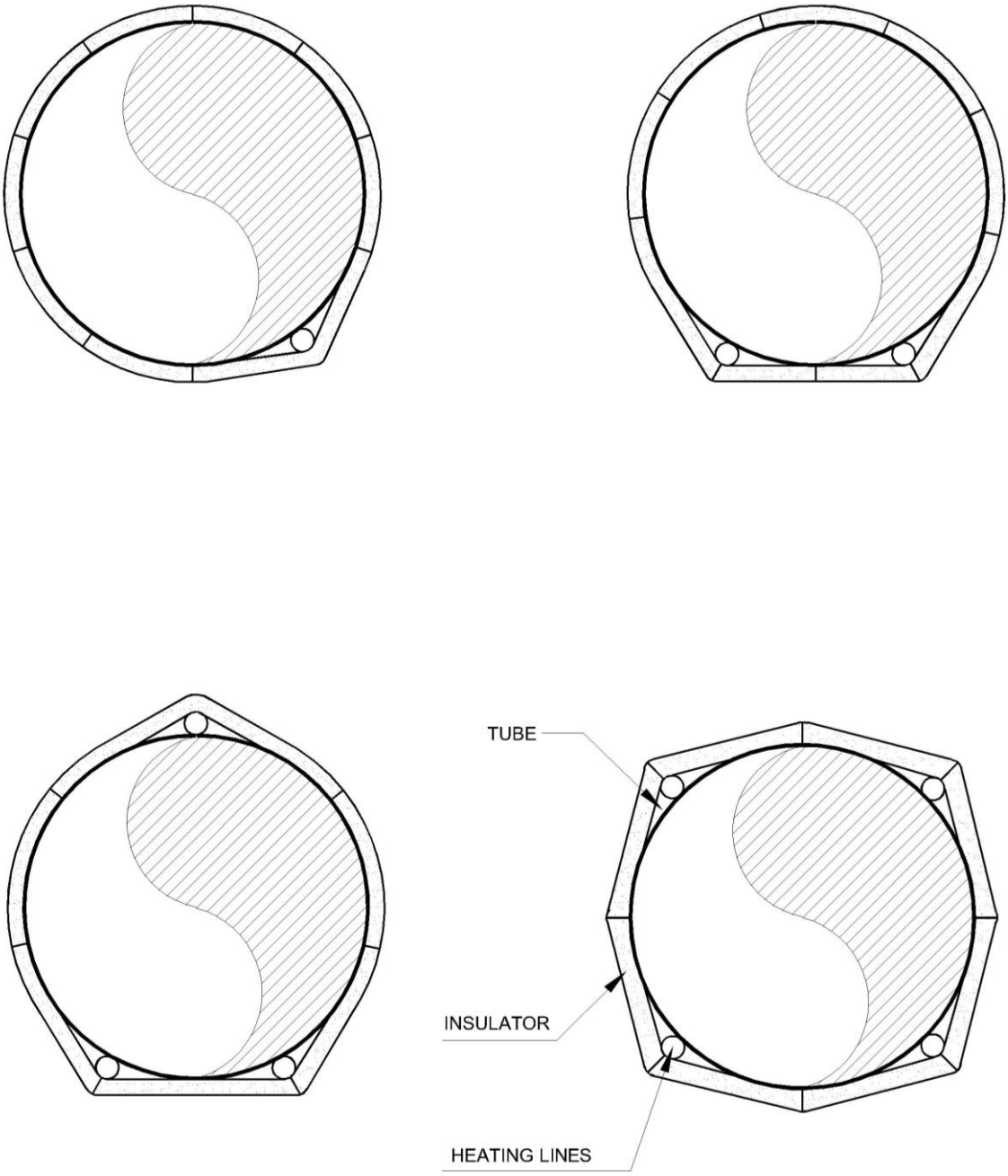
NOTES 1) L = WIDTH THAT SHALL BE LEFT FOR SYSTEM DILATATION.
2) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-2 - Seal



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-3 - Rigid Thermal Insulation for Piping of NPS 8 Diameter with Heating Lines



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-4 - Rigid Thermal Insulation with Segment in Tubes of Diameter above NPS 8 with Heating Lines

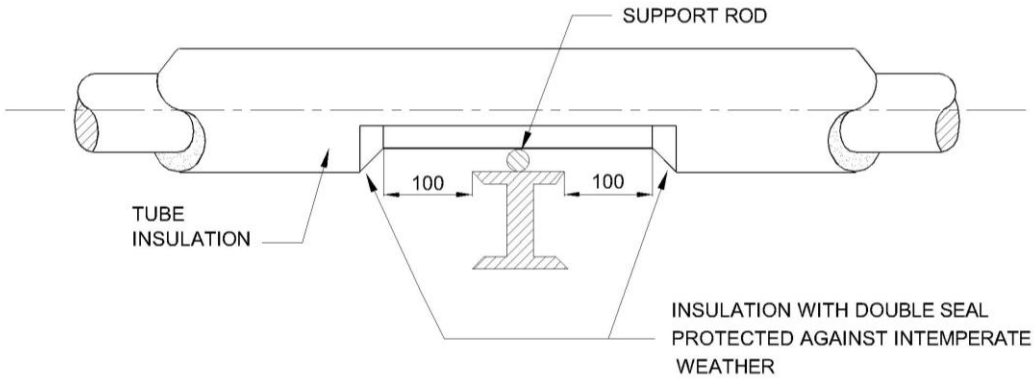


FIGURE A-5.1 - Pipes on Supports with Bar

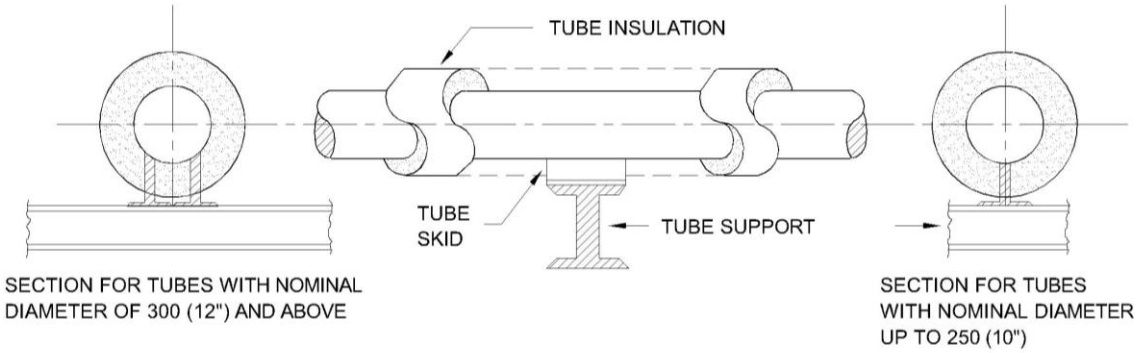
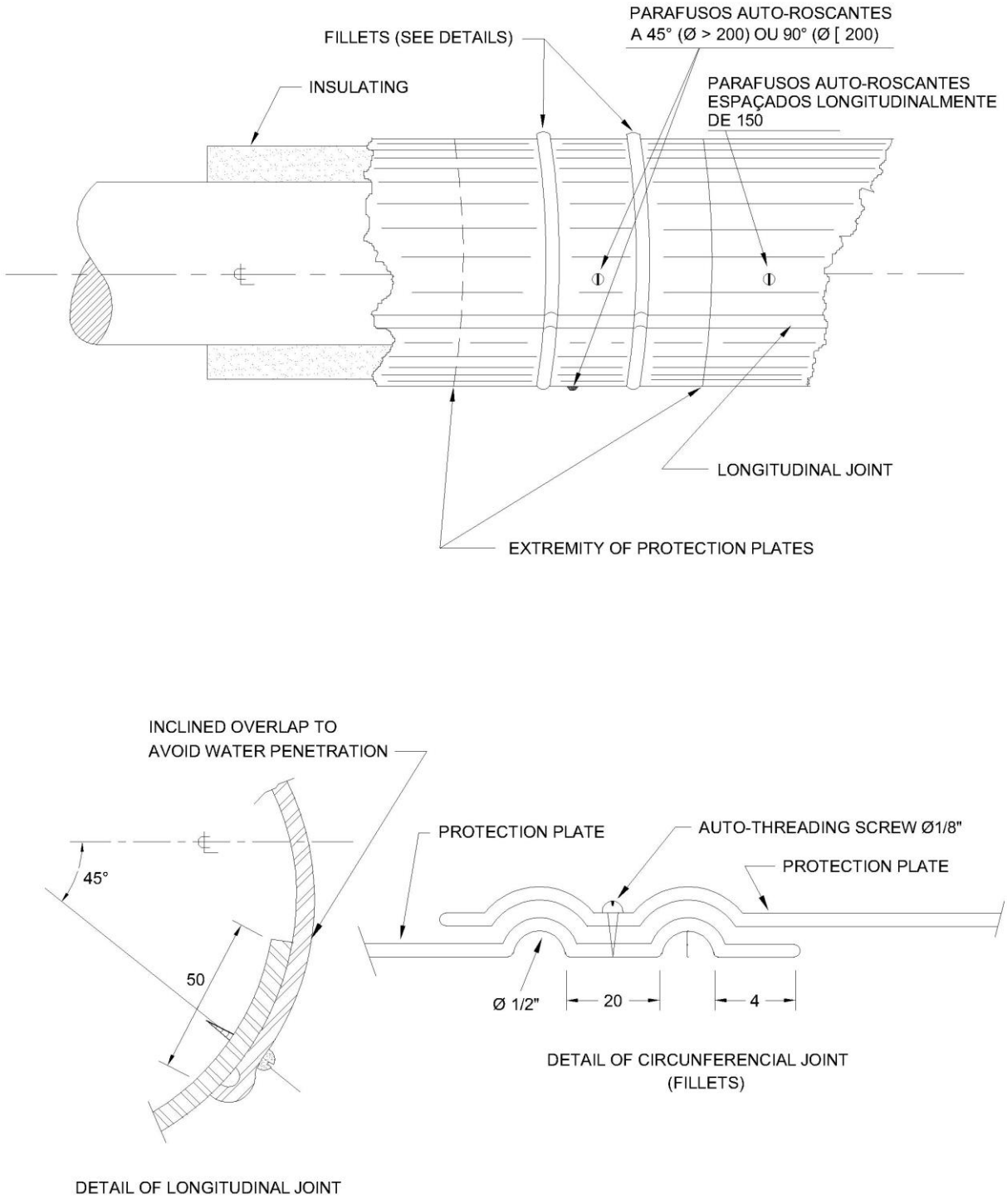


FIGURE A-5.2 - Pipes with Skids

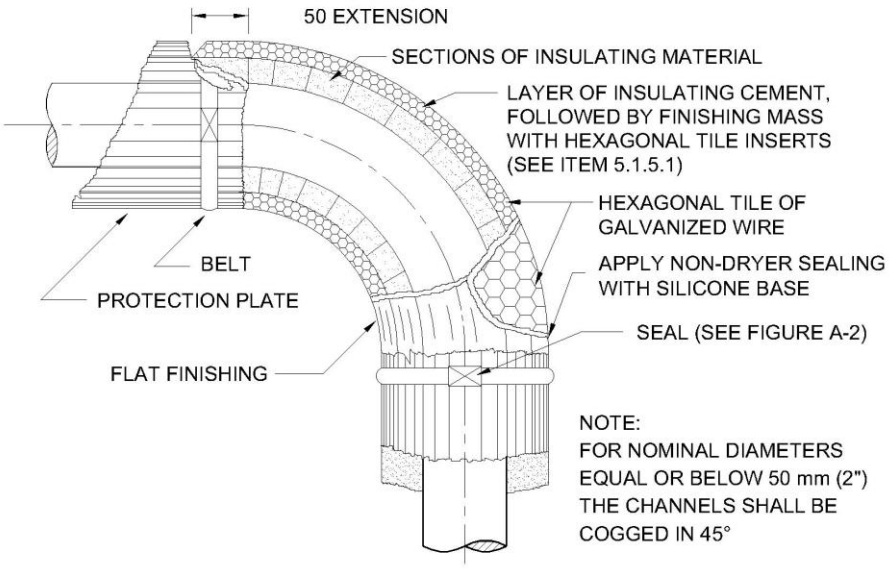
NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

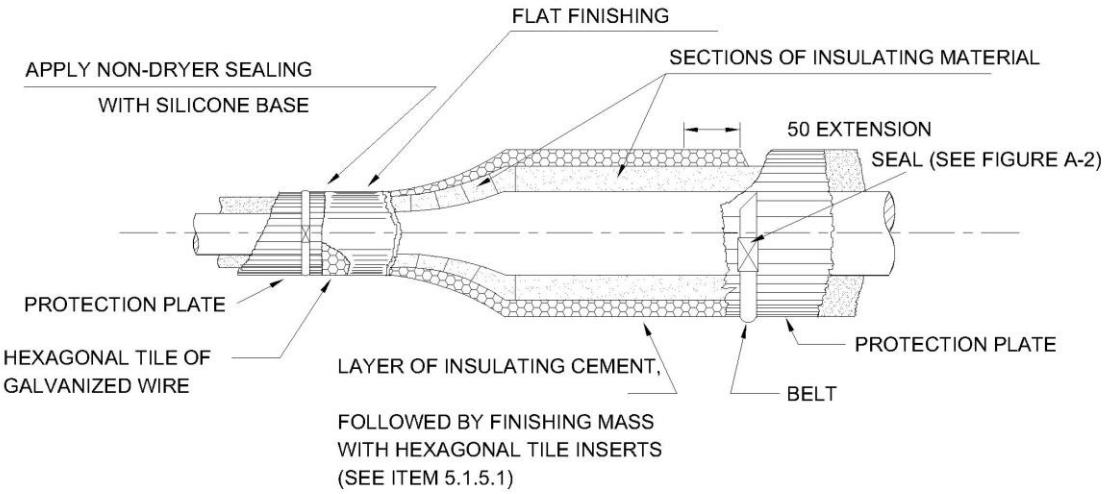
Figure A-5 - Insulation of Pipes In Region of Supports

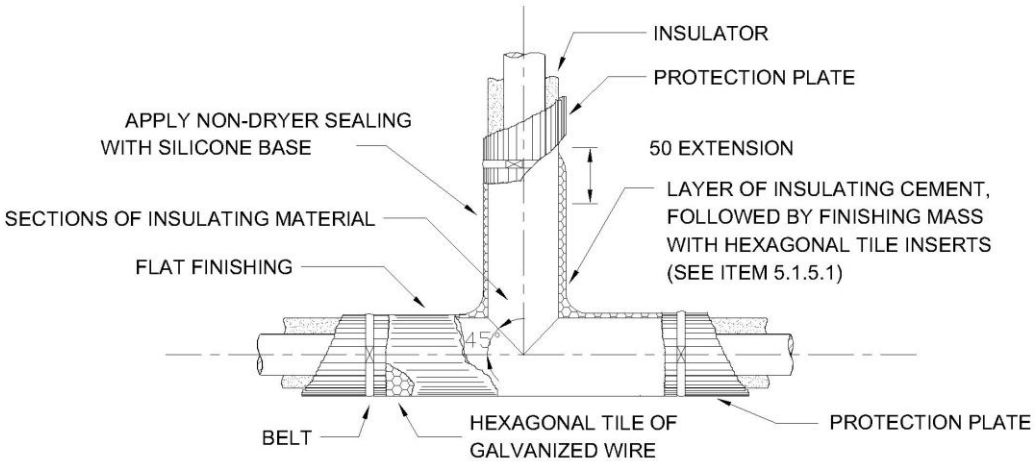


NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-6 - Connection of Protection Sheets

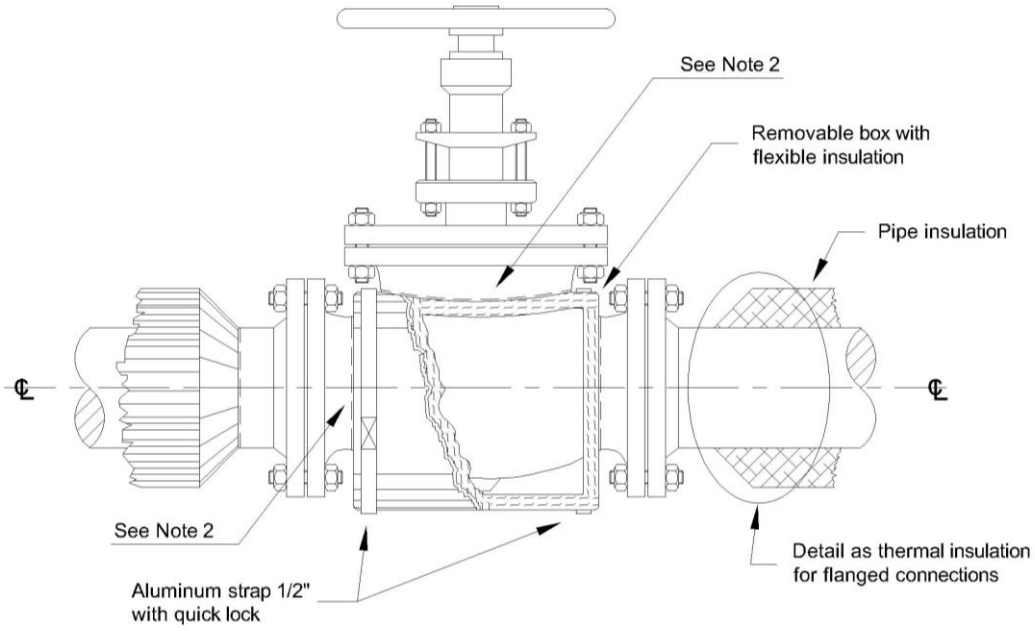




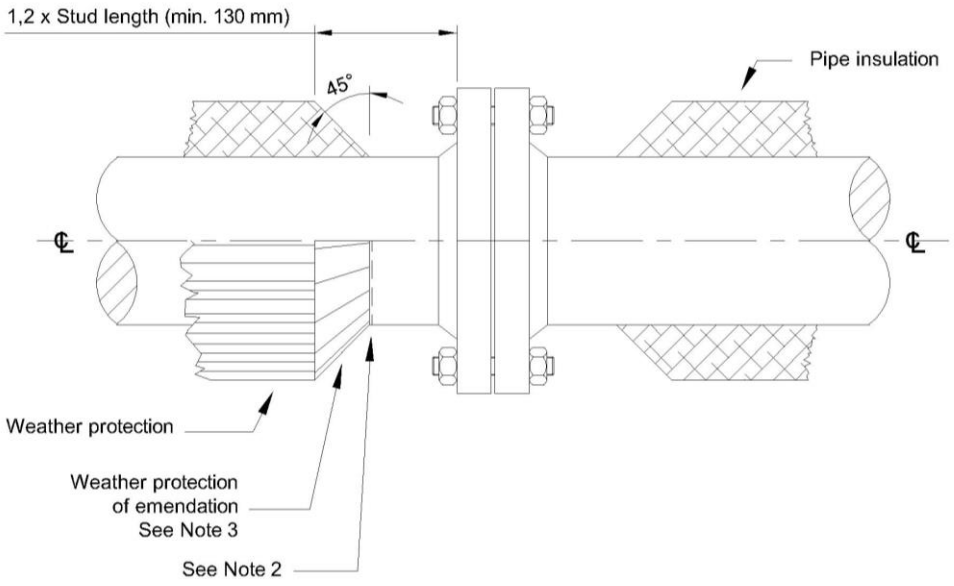


NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-7 -Thermal Insulation of Bends, Tees and Reducers



Thermal Insulation of Valves



Thermal Insulation of Flanged Connections

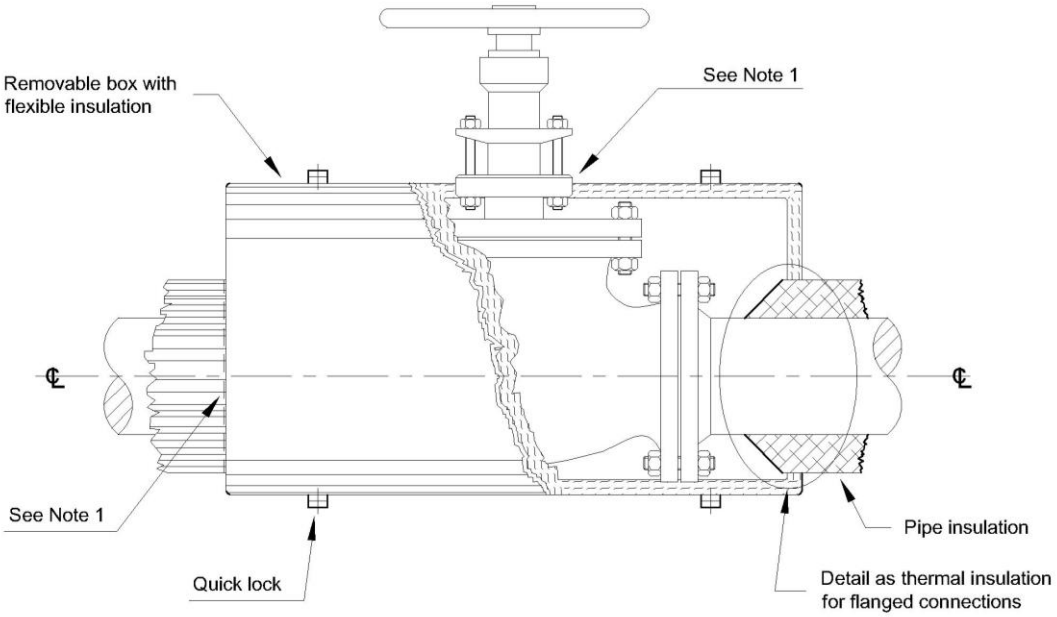
NOTE 1 The thermal insulation near to the flanges must be executed in such a way that allow the removal of their studs without causing dameges to the system.

NOTE 2 At temperatures up to 260 °C, applying sealant not dryable (silicone rubber based) into the openings interference with the valve or pipe.

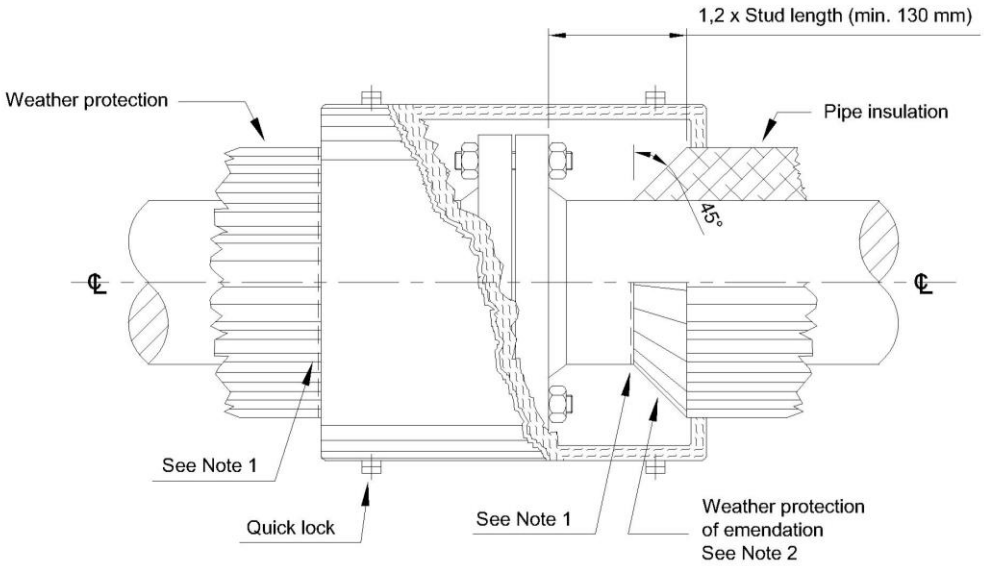
NOTE 3 Weater protection or thermal insulation at emendation with finishing mass on asphalt base (up to 93 ºC) or aluminum foil (for any temperature.

Figure A-8.1 – White Flanges Exposed (not Insulated)

Figure A-8 - Insulation of Valves and Flanges



Thermal Insulation of Valves

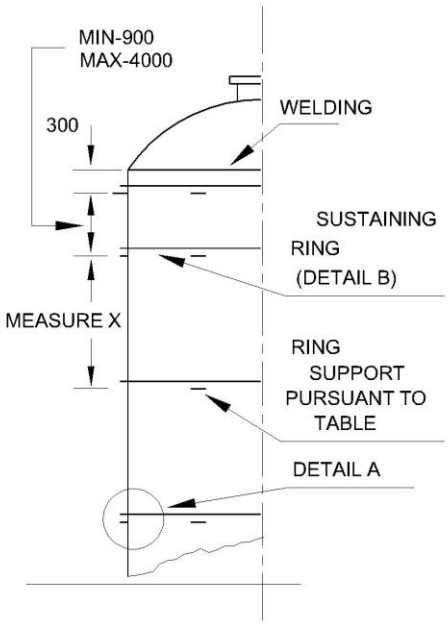


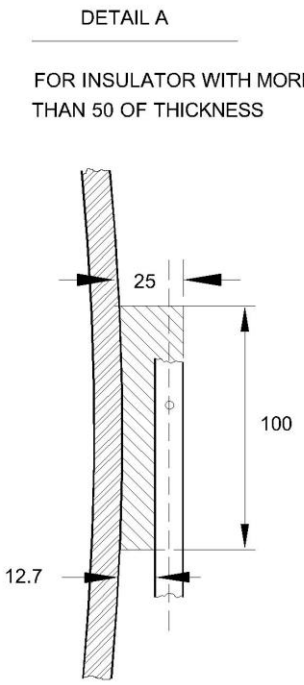
Thermal Insulation of Flanged Connections

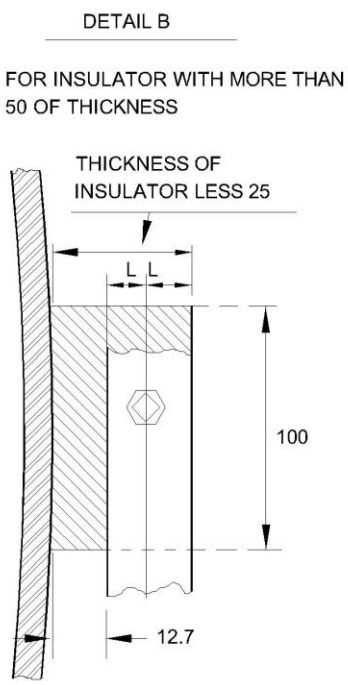
NOTE 1 At temperatures up to 260 °C, applying sealant not dryable (silicone rubber based) into the openings interference with the valve or pipe.
NOTE 2 Weater protection or thermal insulation at emendation with finishing mass on asphalt base (up to 93 ºC) or aluminum foil (for any temperature.
NOTE 3 Thermal insulation of flanged connections should executed only when forecast in project.
NOTE 4 The thermal insulation near to the flanges must be executed in such a way that allow the removal of their studs without causing dameges to the system.

Figure A-8.2 – Whit Insulated Flanges

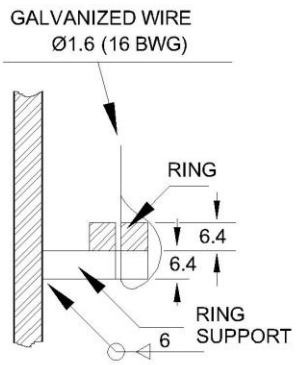
Figure A-8 - Insulation of Valves and Flanges

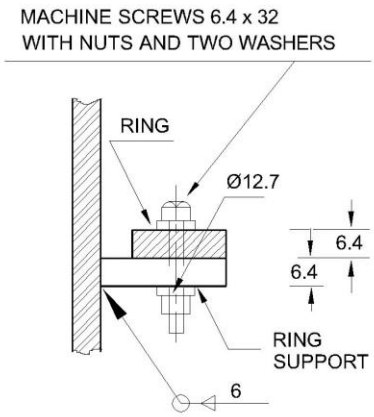


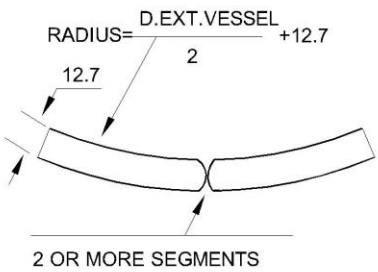


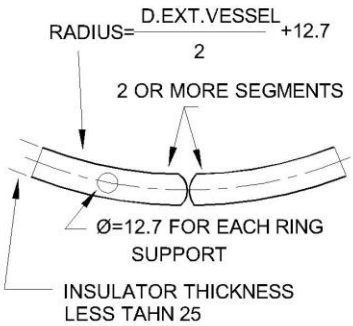


VESSEL DIAMETER (mm)	NO. OF RING SUPPORTS
up to 1 200	4
1 210 to 2 400	6
2 410 to 3 600	8
3 610 to 4 800	10
4 810 to 6 000	12
6 010 to ABOVE	WITH SPACE OF 1.5 m



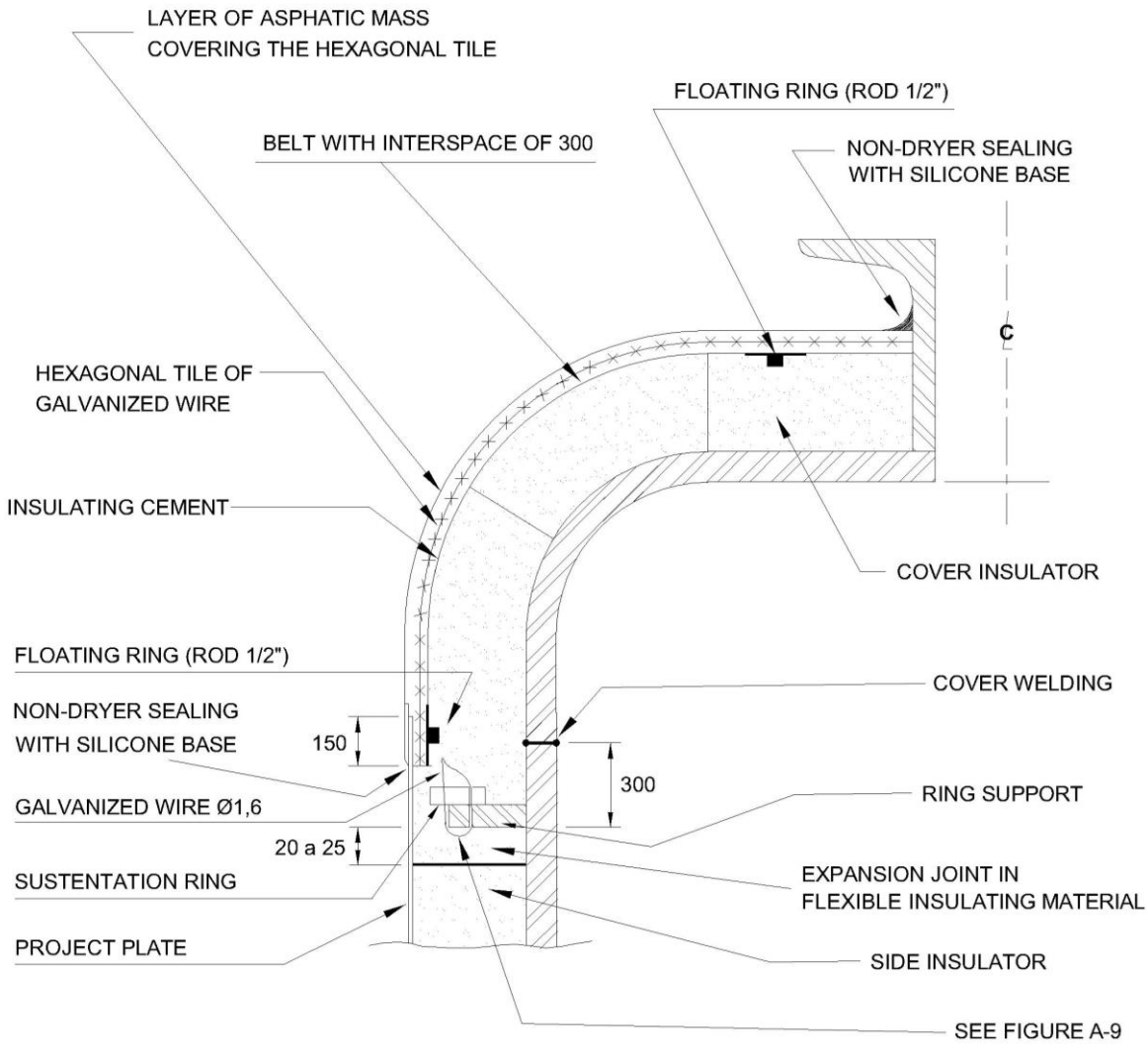






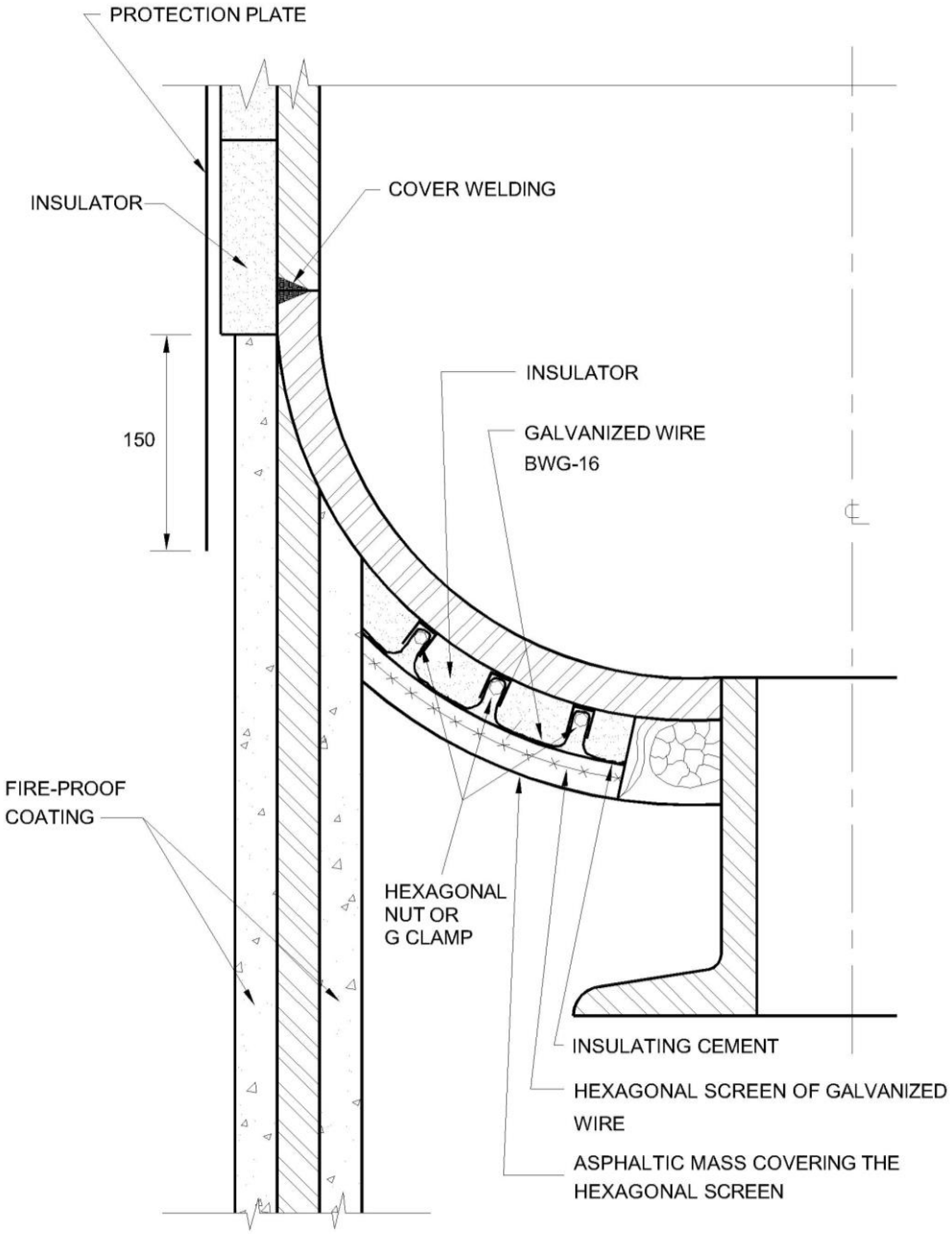
NOTES: 1) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.
2) MEASURE X:
A) FOR INSULATOR COATING WITH RIGID MATERIAL EQUAL TO 4 000.
B) FOR INSULATOR COATING WITH FLEXIBLE MATERIAL EQUAL TO 3 050.

Figure A-9 - Ring for Supporting Insulation on Vessels



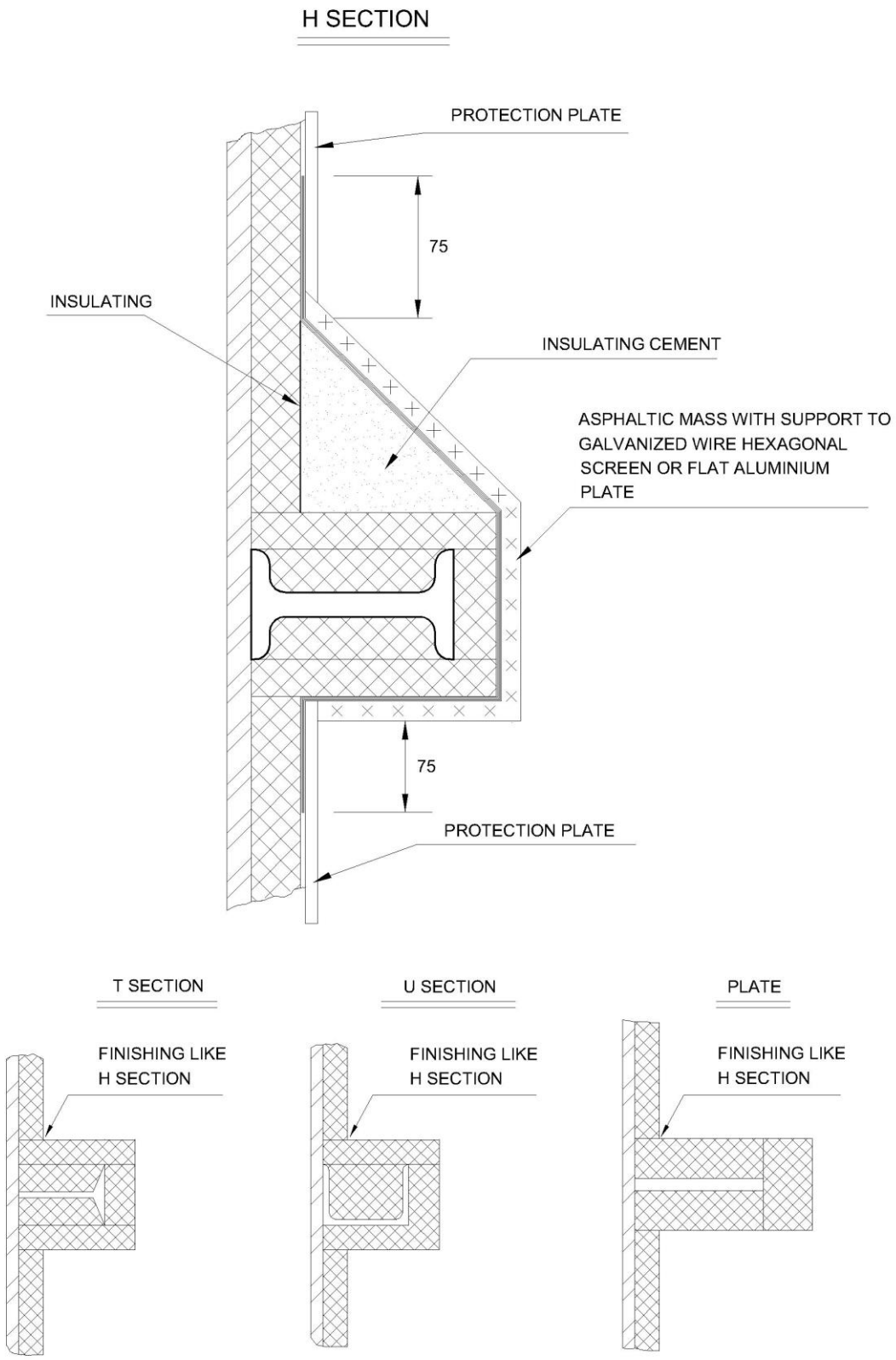
NOTE: DIMENSIONS IN MILLIMETERS, EXPECT IF INDICATED OTHERWISE.

Figure A-10 - Heads of Horizontal And Vertical Vessels



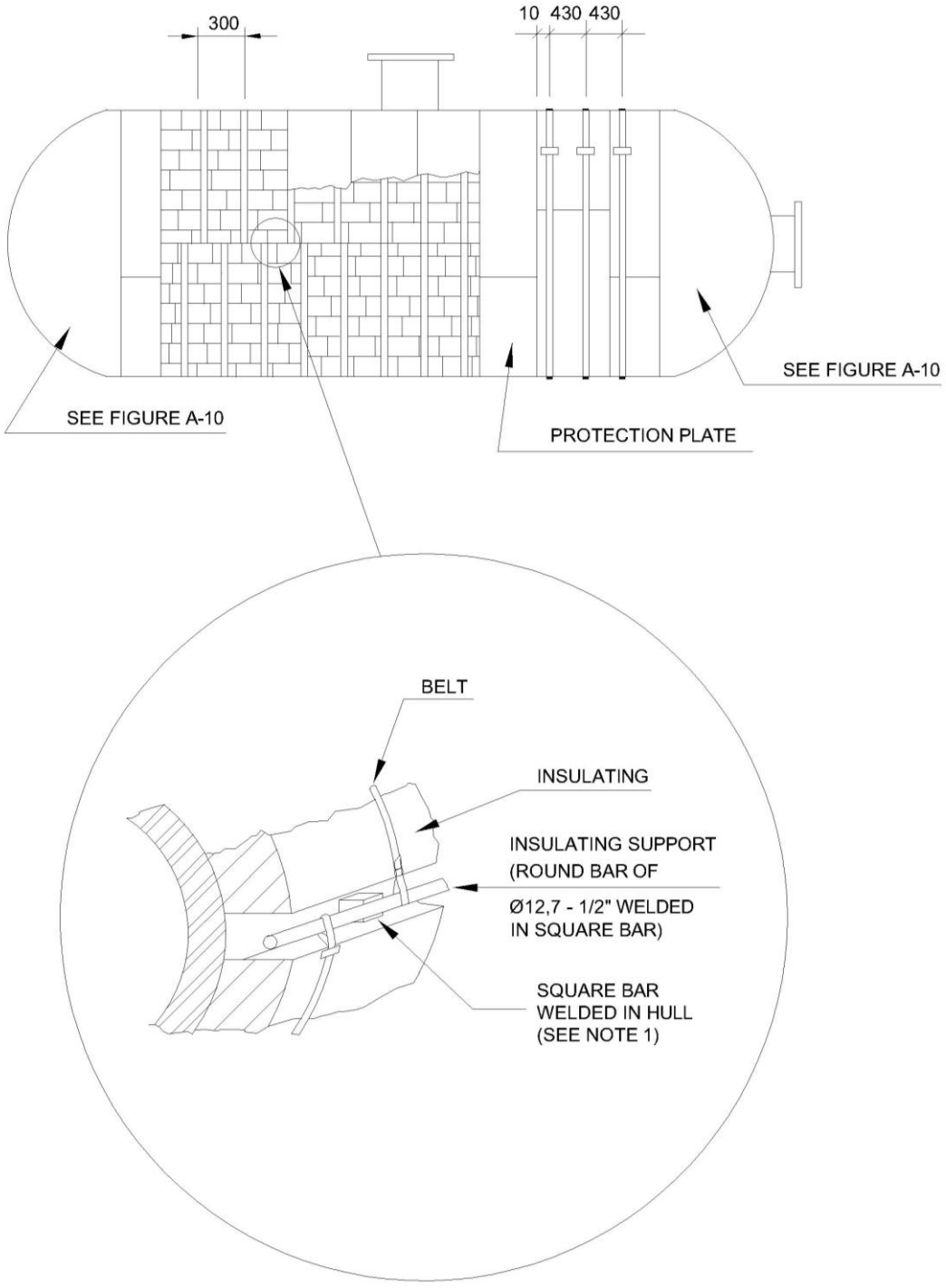
NOTES: 1) VESSELS WITHOU FIRE PROTECTION NEED A RING POSITIONED 300 BELOW THE HULL COVER WELDING FOR INSULATING SUSTANTATION.
2) DIMENSIONS IN MILLIMETERS, EXPECT IF INDICATED OTHERWISE.

Figure A-11 - Bottom Head of Vertical Vessels



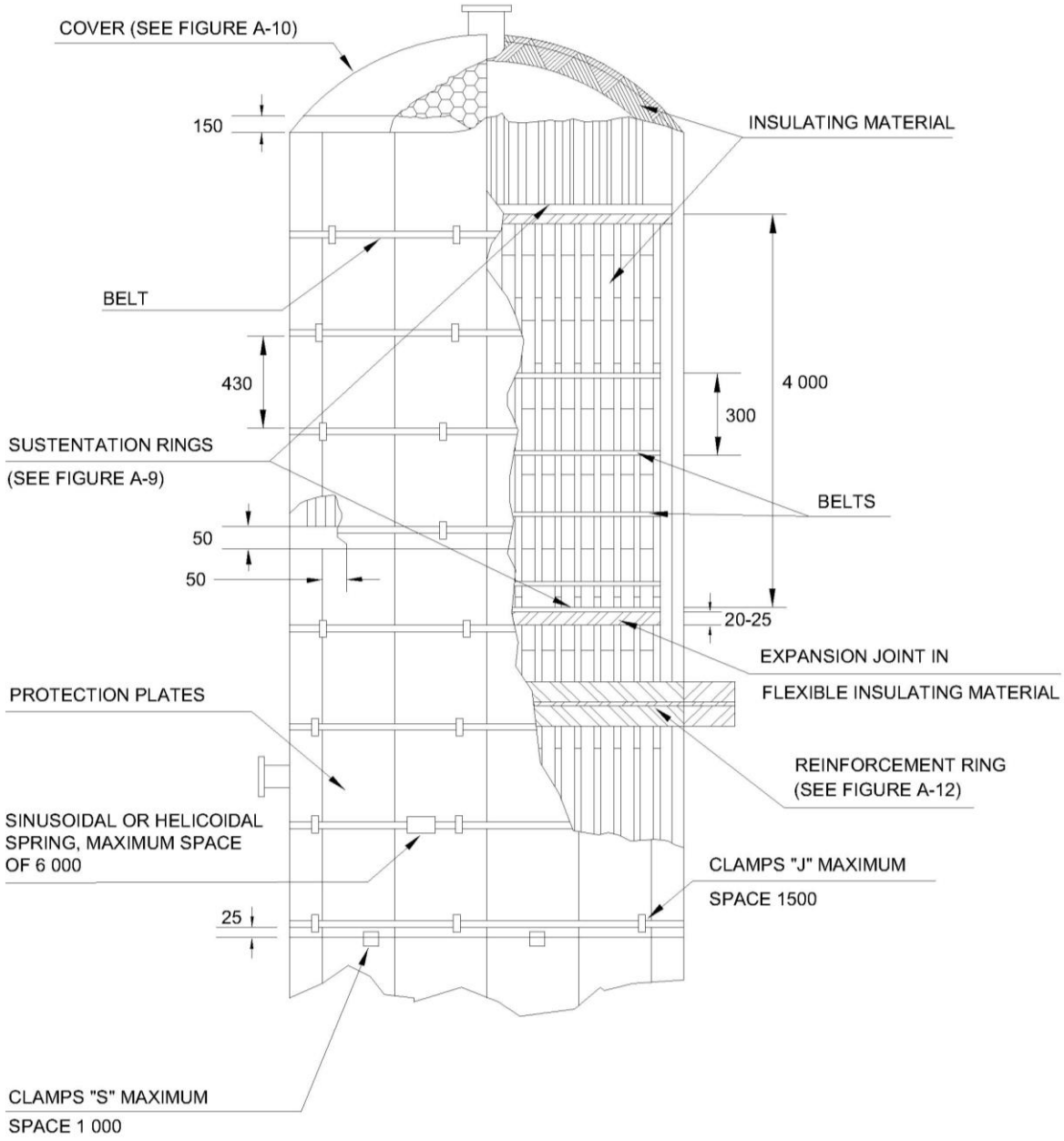
NOTES: 1) THE THICKNESS OF THE REINFORCEMENT RING INSULATOR SHALL BE EQUAL TO THE EQUIPMENT INSULATOR, NO MORE THAN 75.
2) DIMENSIONS IN MILLIMETERS, EXPECT IF INDICATED OTHERWISE.

Figure A-12 - Insulation of Reinforcement Rings



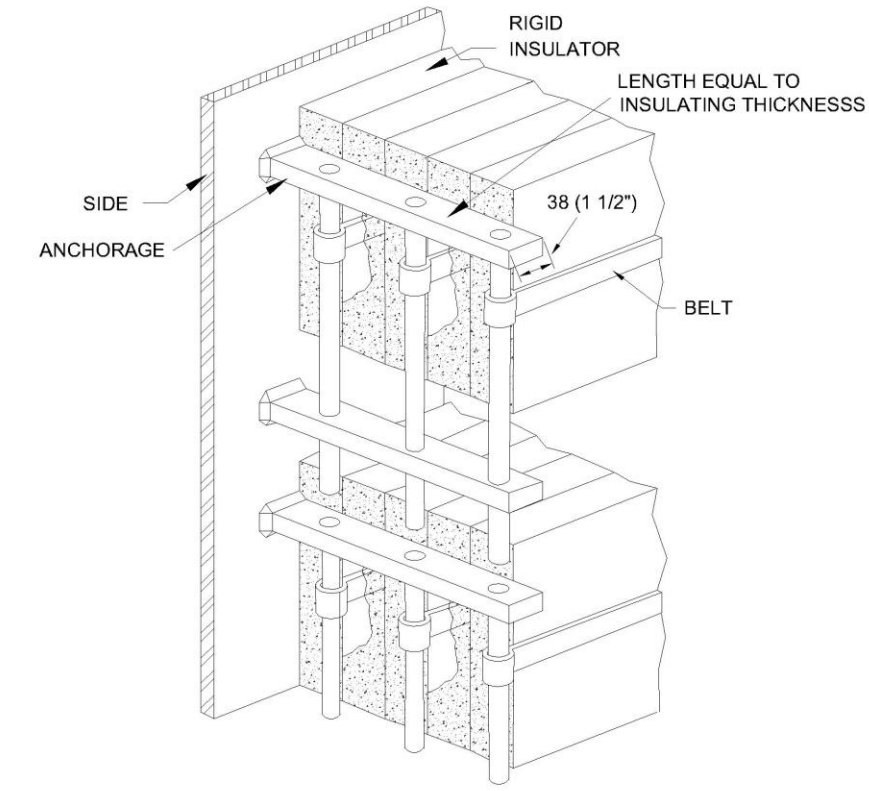
NOTES: 1) THE SQUARE BAR HAVE A 19 x 19 SECTION, HEIGHT EQUAL TO HALF OF THE INSULATOR'S FIRST LAYER THICKNESS AND SPACE OF 1 000.
2) DIMENSIONS IN MILLIMETERS, EXPECT IF INDICATED OTHERWISE.

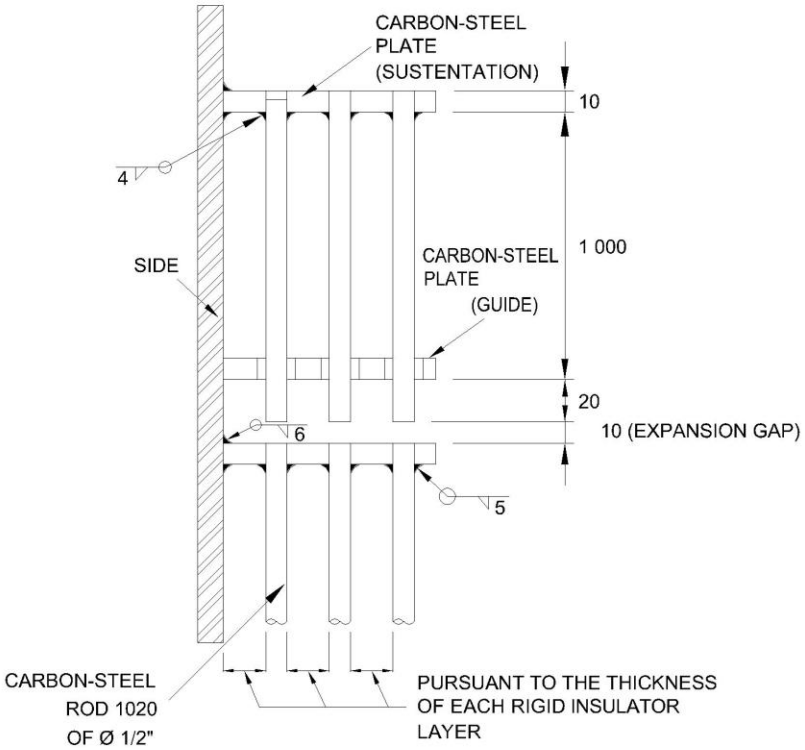
Figure A-13 - Thermal Insulation in Horizontal Vessels (Shell Diameter Over 1800)



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-14 - Rigid Thermal Insulation in Vertical Vessels





NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-15.1 - Anchoring System for Rigid Insulation

Figure A-15 - Insulation of Coke Reactor

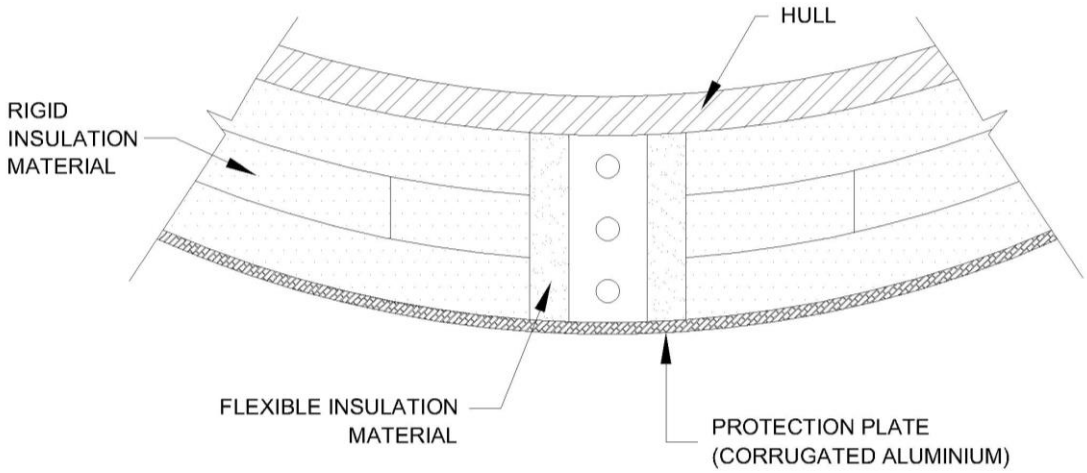
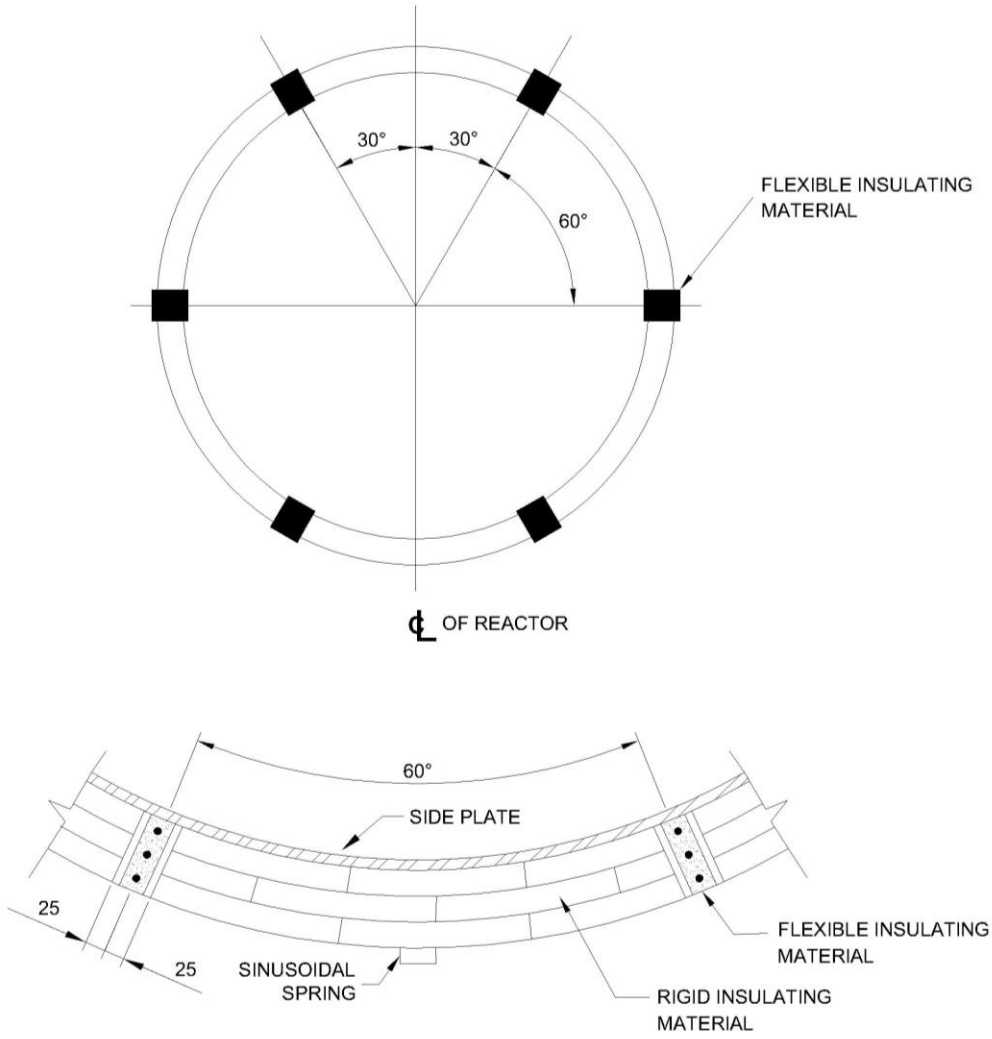


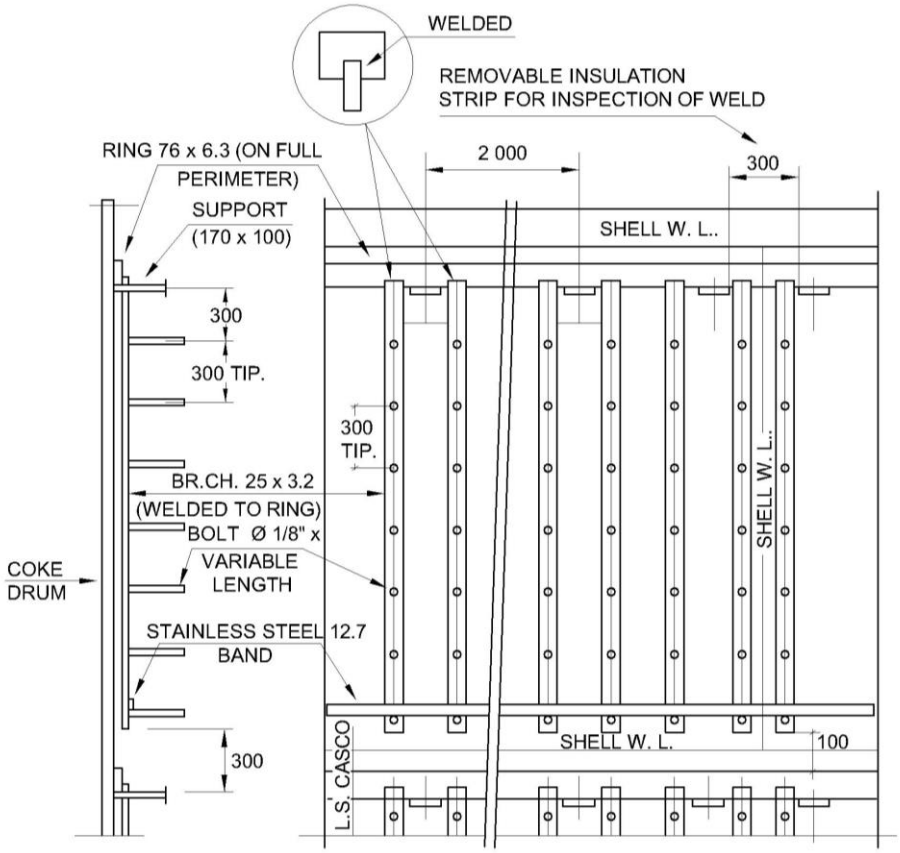
Figure A-15.2 - Detail of Expansion Joint

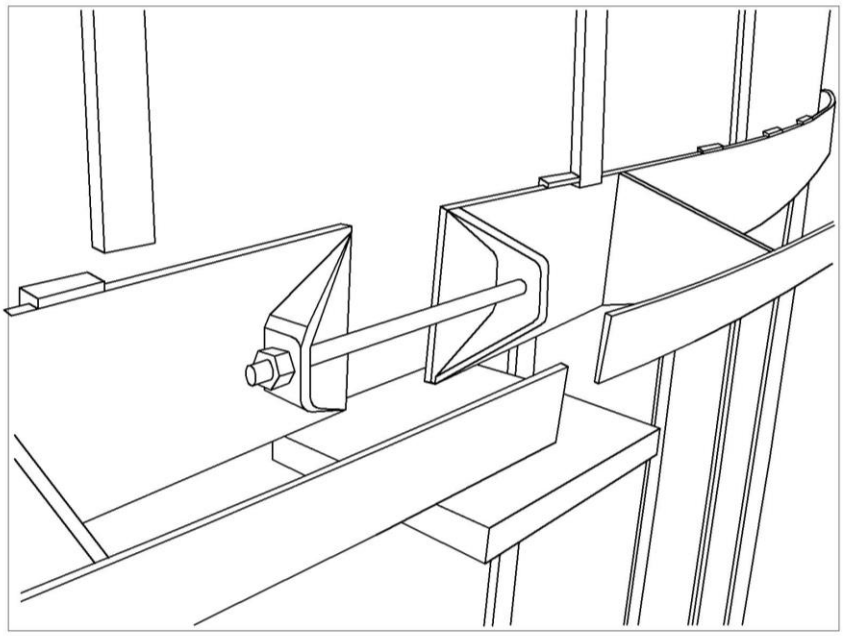


NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-15.3 - Spacing of Anchorage for Rigid Insulation

Figure A-15 - Insulation of Coke Reactor

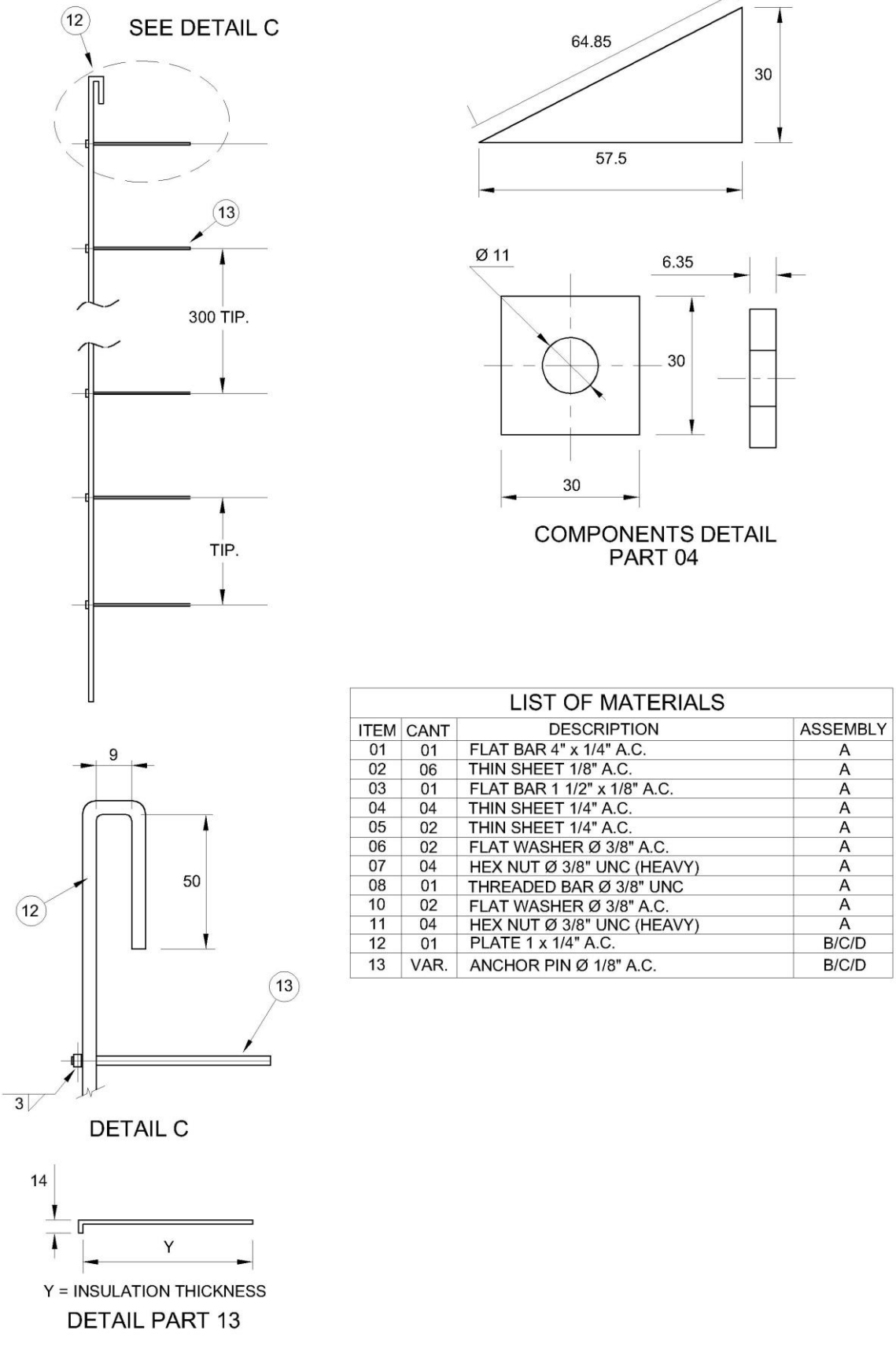




NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-15.4 - Floating Anchorage System for Flexible Thermal Insulation

Figure A-15 - Insulation of Coke Reactor



LIST OF MATERIALS			
ITEM	CANT	DESCRIPTION	ASSEMBLY
01	01	FLAT BAR 4" x 1/4" A.C.	A
02	06	THIN SHEET 1/8" A.C.	A
03	01	FLAT BAR 1 1/2" x 1/8" A.C.	A
04	04	THIN SHEET 1/4" A.C.	A
05	02	THIN SHEET 1/4" A.C.	A
06	02	FLAT WASHER Ø 3/8" A.C.	A
07	04	HEX NUT Ø 3/8" UNC (HEAVY)	A
08	01	THREADED BAR Ø 3/8" UNC	A
10	02	FLAT WASHER Ø 3/8" A.C.	A
11	04	HEX NUT Ø 3/8" UNC (HEAVY)	A
12	01	PLATE 1 x 1/4" A.C.	B/C/D
13	VAR.	ANCHOR PIN Ø 1/8" A.C.	B/C/D

Figure A-15.5 - Detail of Floating Anchorage System for Flexible Insulation

Figure A-15 - Insulation of Coke Reacto

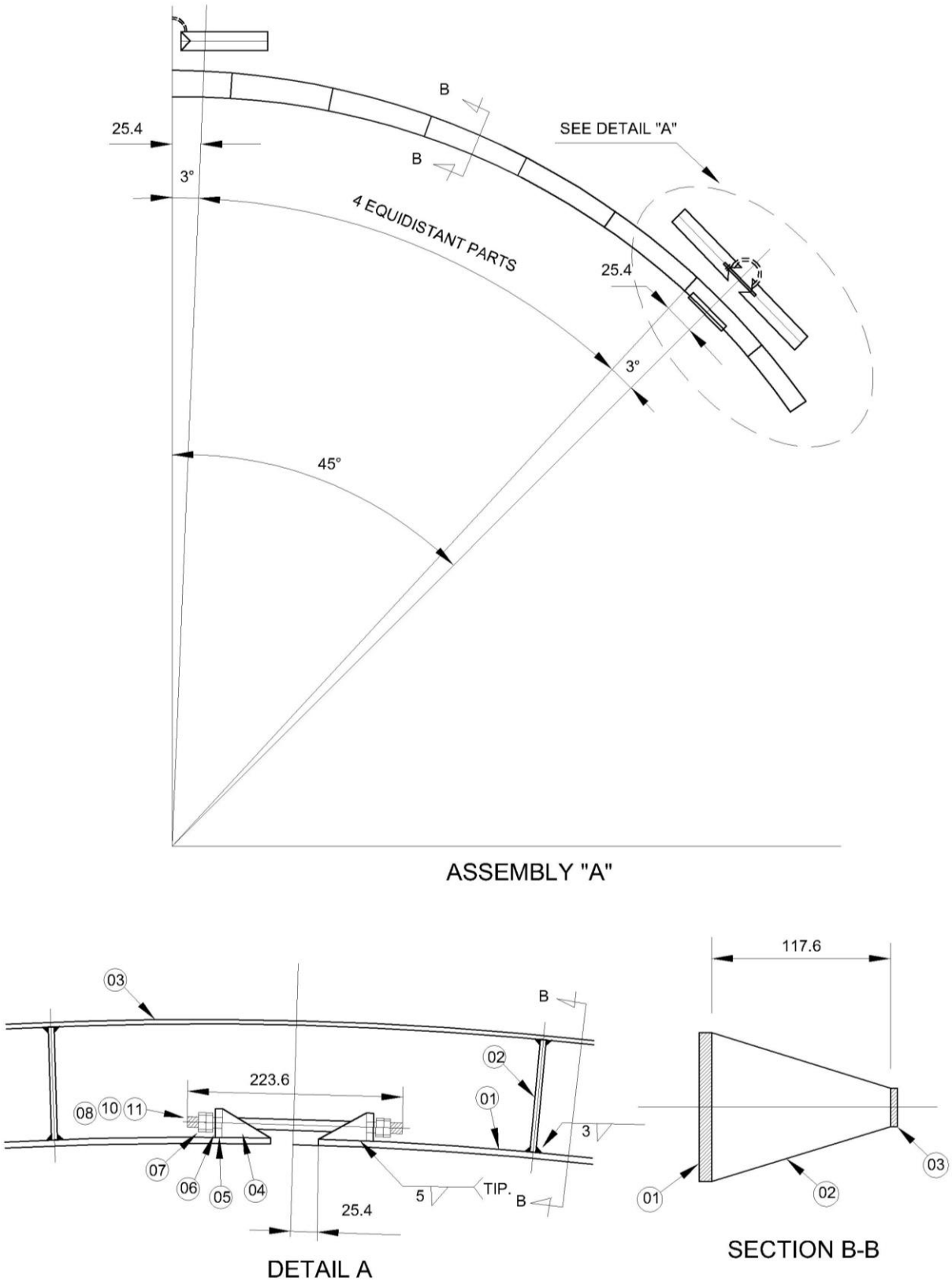
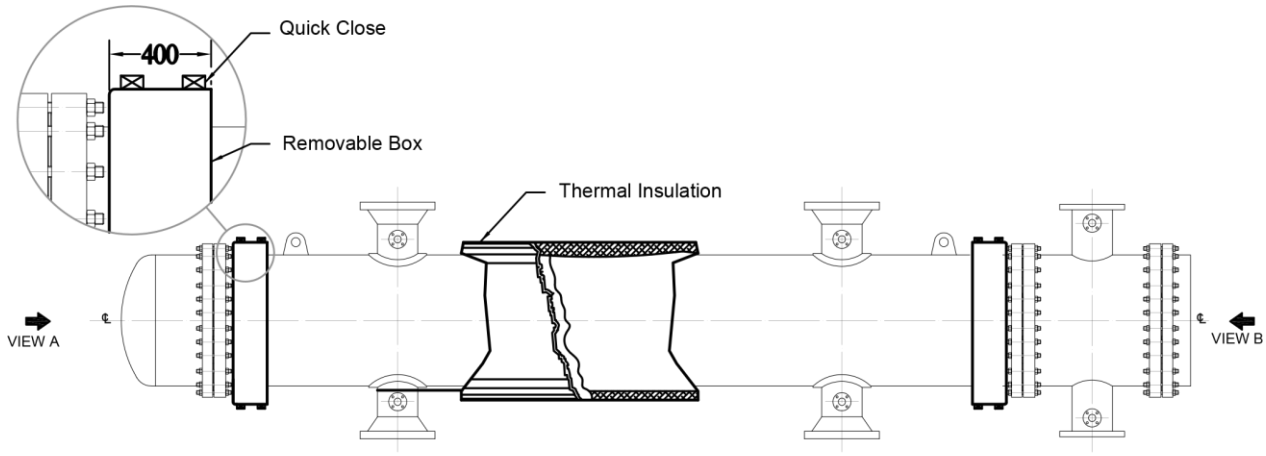
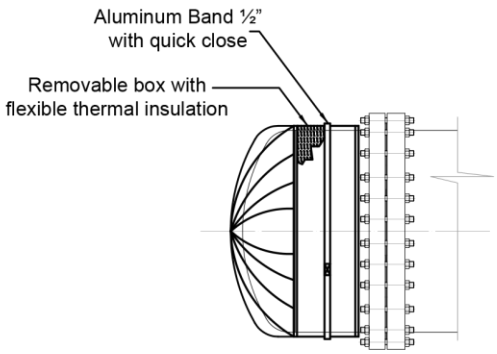


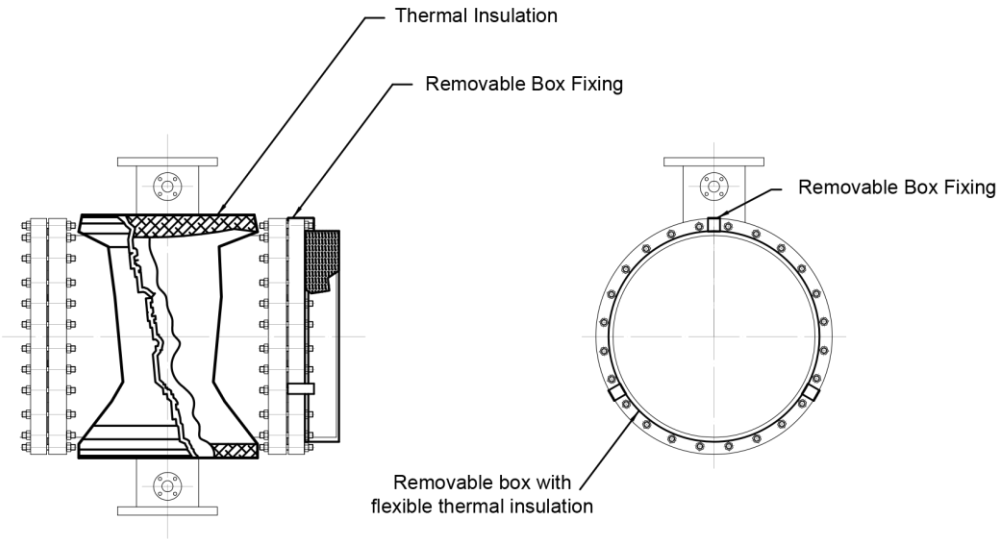
Figure A-15.5 - Detail of Floating Anchorage System for Flexible Insulation (CONTINUED)

Figure A-15 - Insulation of Coke Reactor





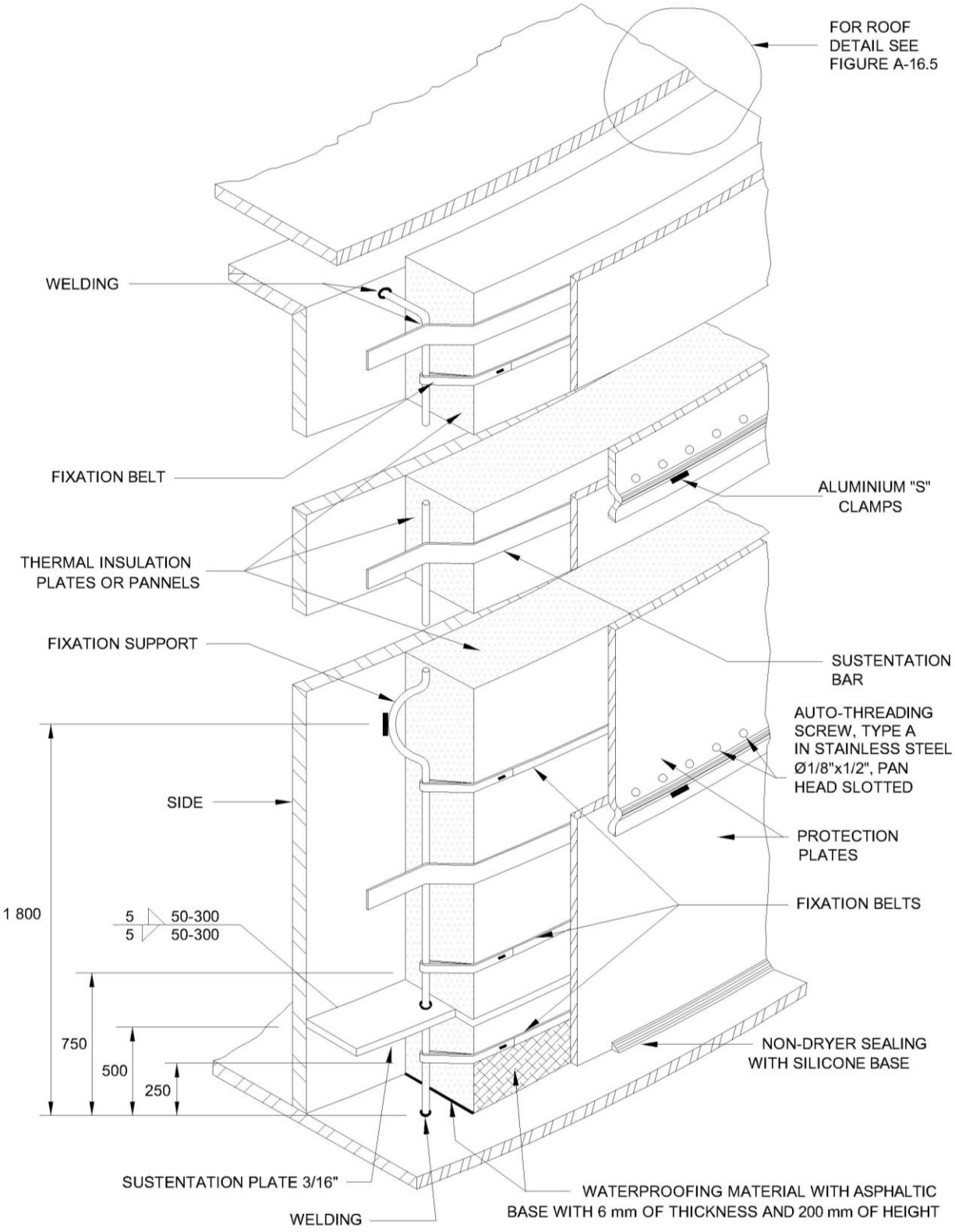
View - A



View - B

NOTE Dimensions in millimeters, except othersive indication.

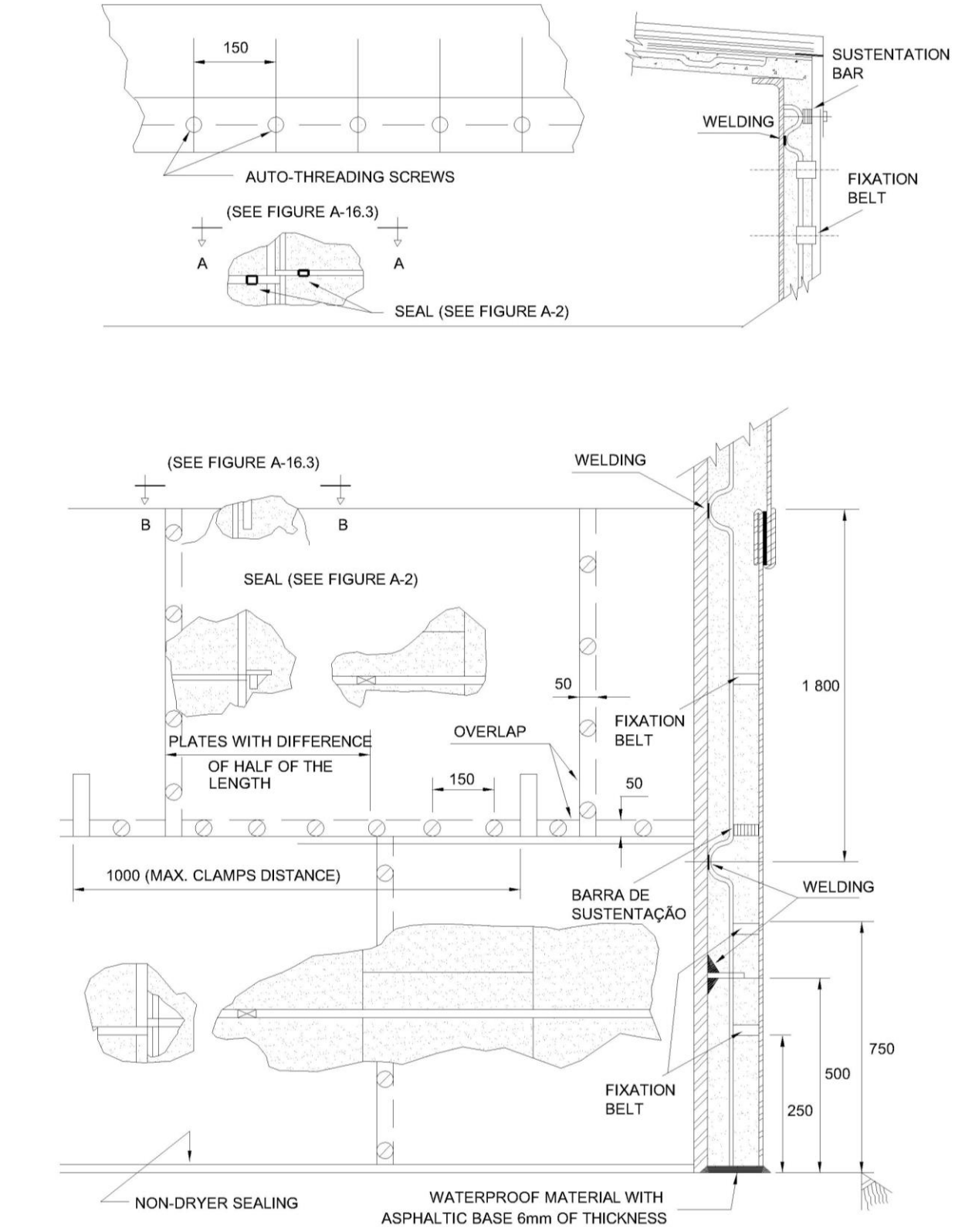
Figure A.16 – Thermal Insulation for Heat Exchanges



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-17.1 - General Arrangement

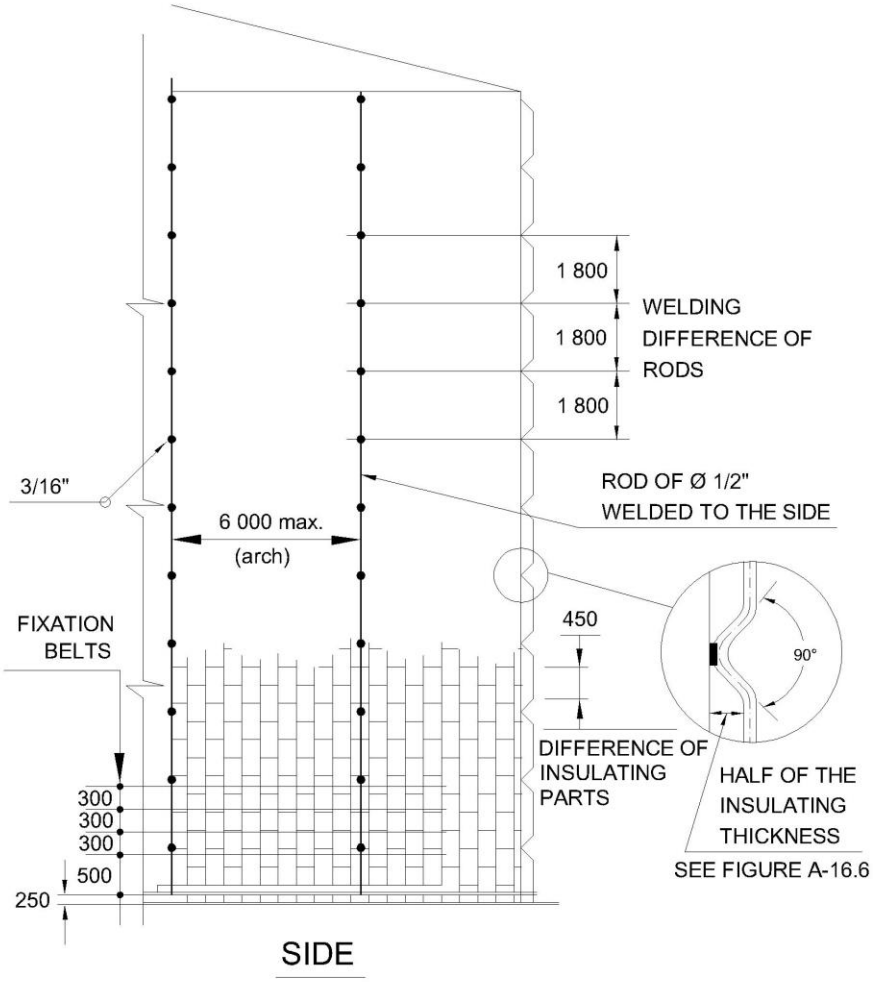
Figure A-17 - Thermal Insulation for Tanks (Alternative 1)

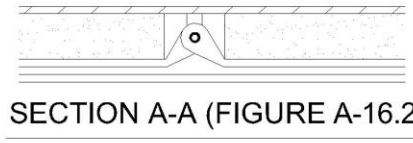


NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

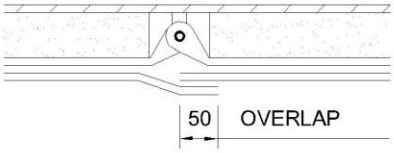
Figure A-17.2 –Assembly Details

Figure A-17 – Thermal Insulation for Tanks (Alternative 1)





SECTION A-A (FIGURE A-16.2)

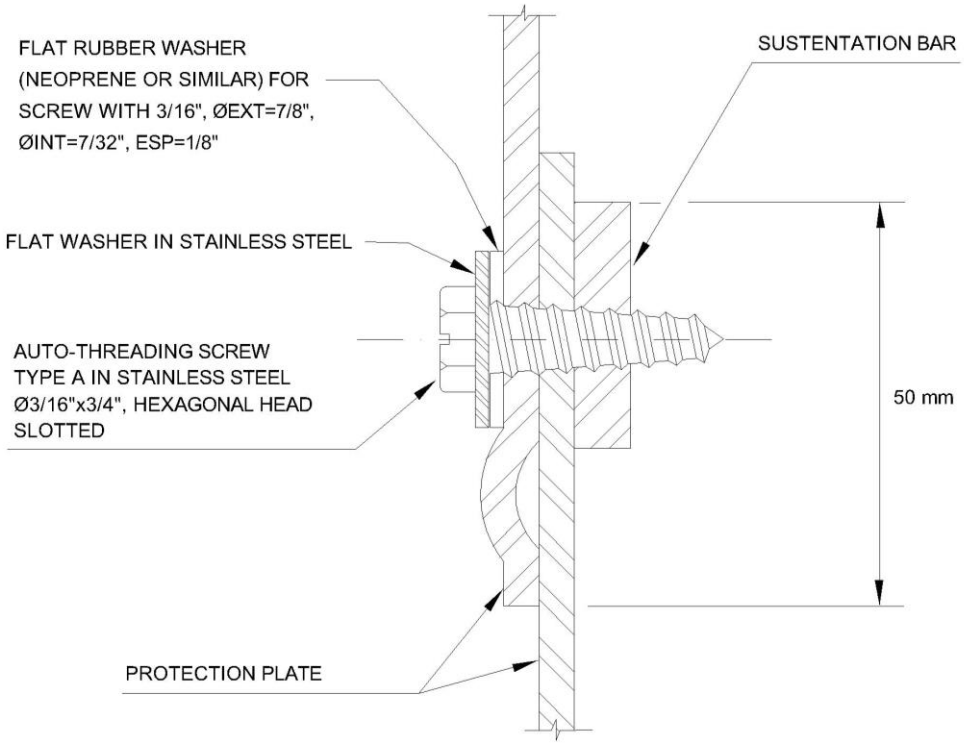


SECTION B-B (FIGURE A-16.2)

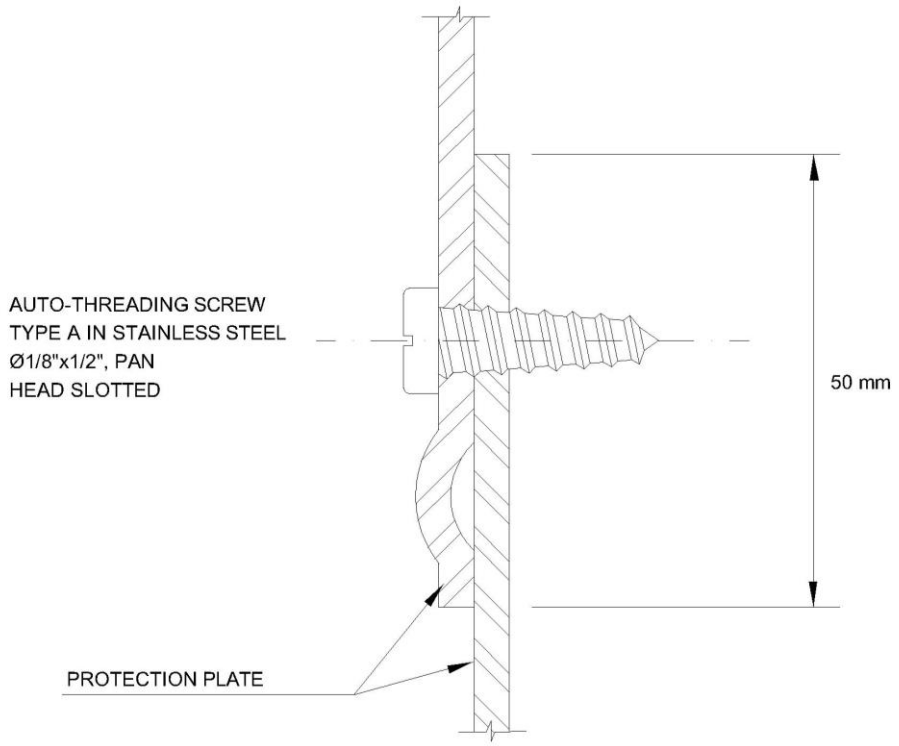
NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-17.3 – Assembly Details

Figure A-17 – Thermal Insulation for Tanks (Alternative 1)



FIXATION OF PROTECTION PLATES IN SUSTENTATION BARS

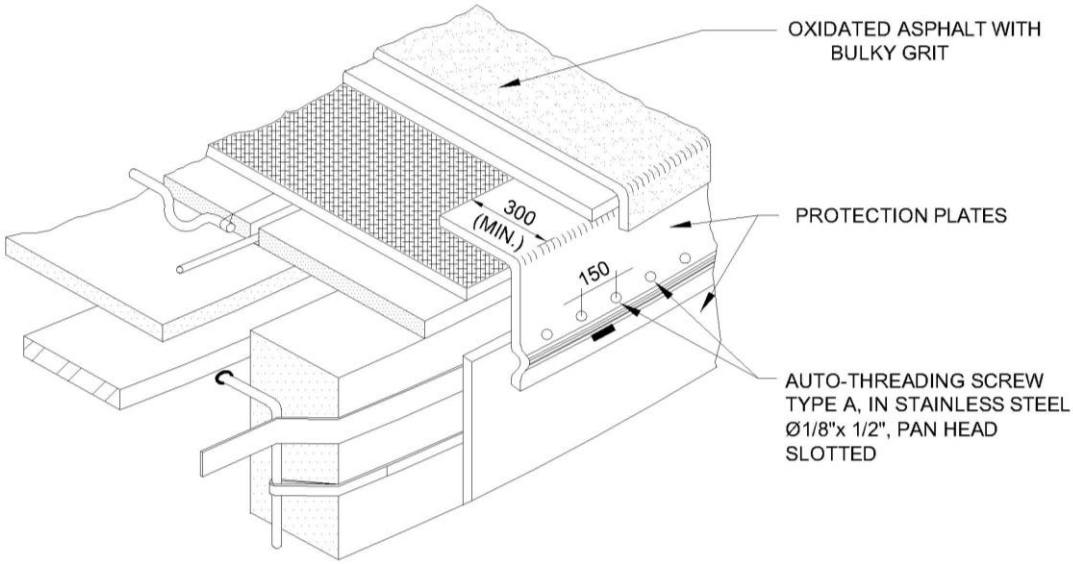


FIXATION BETWEEN PROTECTION PLATES IN VERTICAL WAY

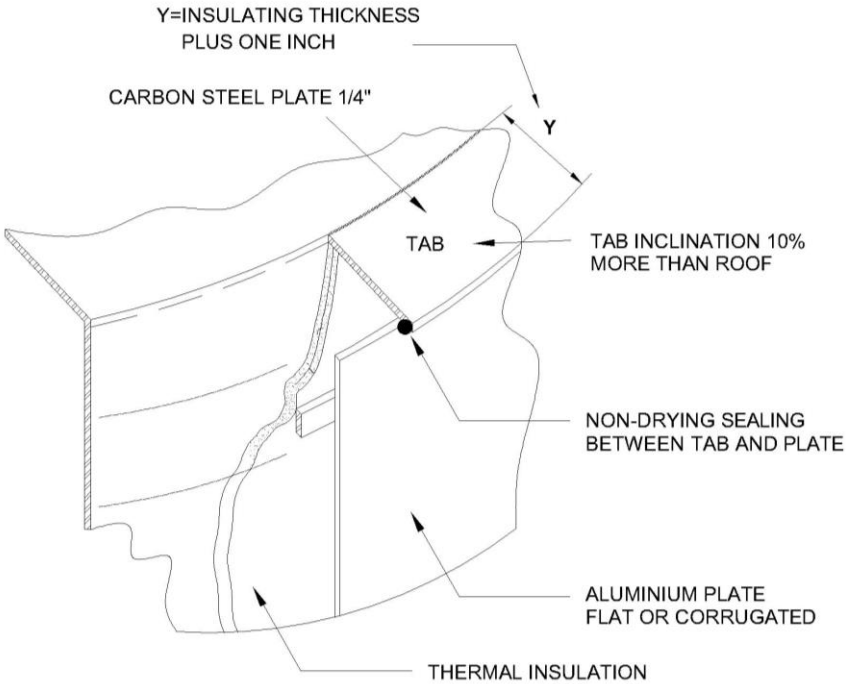
NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-17.4 – Details of Attachment of Protection Sheets

Figure A-17 – Thermal Insulation for Tanks (Alternative 1)



TYPICAL DETAIL FOR ROOF WITH THERMAL INSULATION

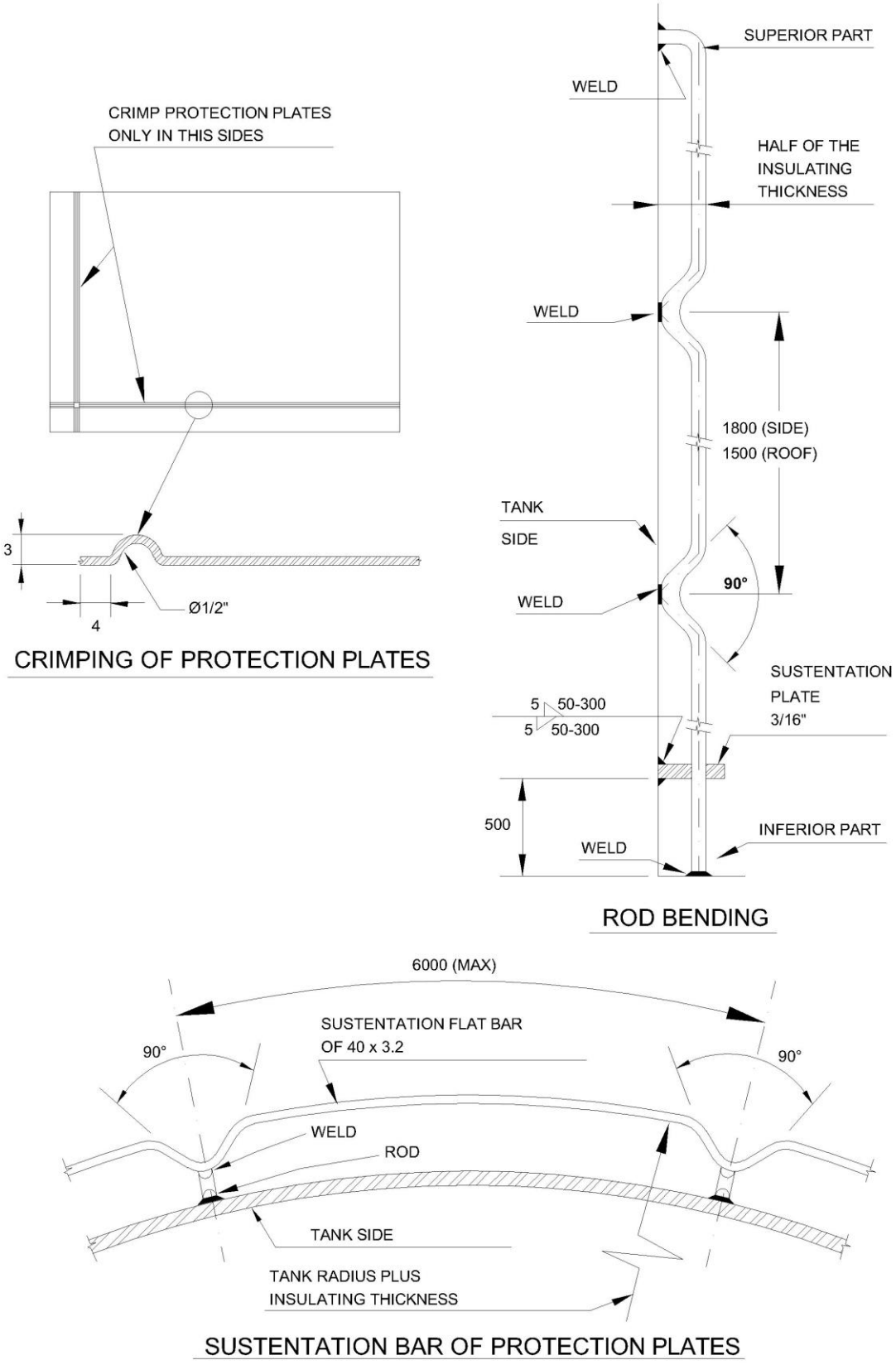


TYPICAL TAB DETAIL FOR ROOF WITHOUT THERMAL INSULATION

NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-17.5 – Assembly Details in the Roof-to-Shell Transition Region

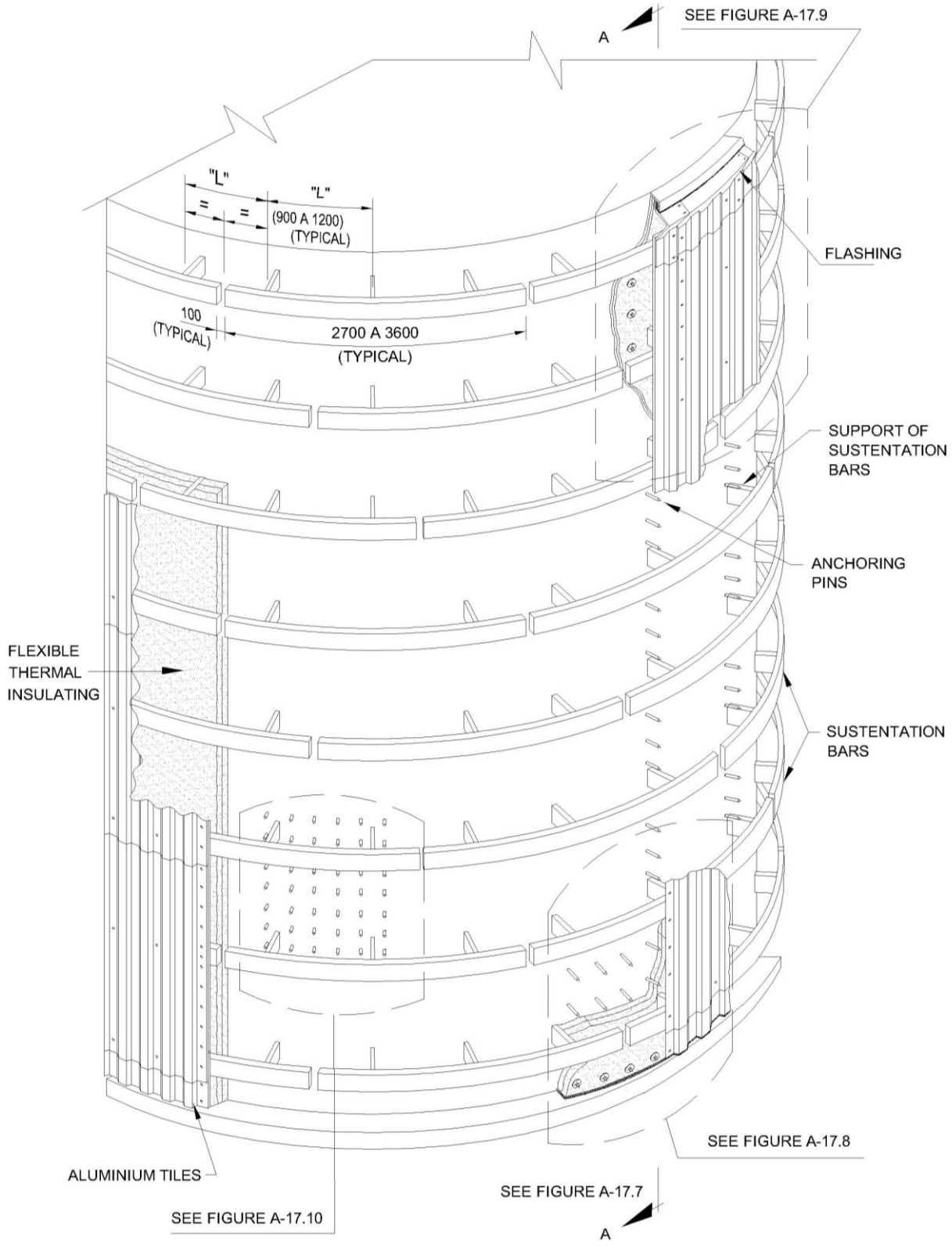
Figure A-17 – Thermal Insulation for Tanks (Alternative 1)



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-17.6 – Bending Details

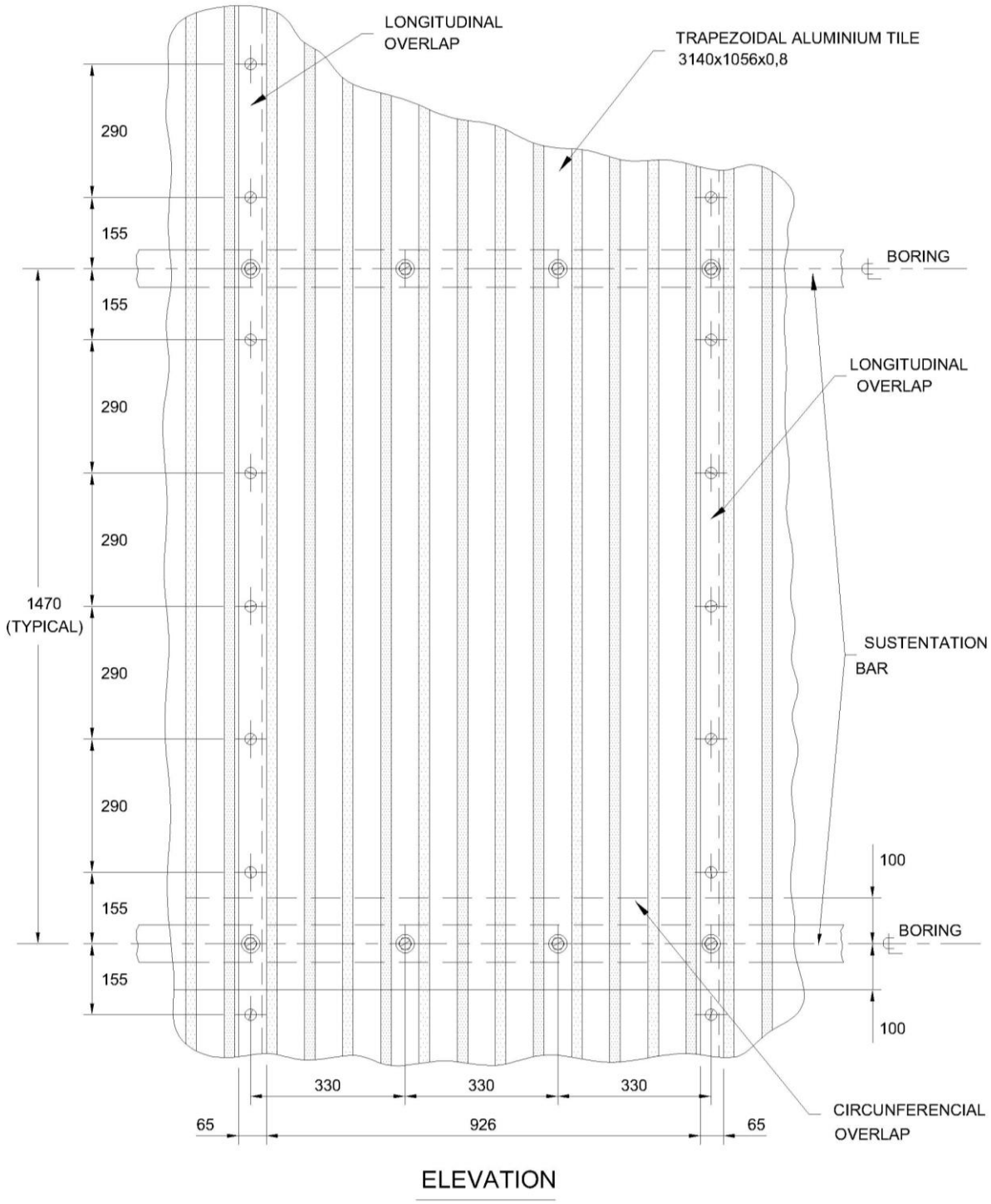
Figure A-17 – Thermal Insulation for Tanks (Alternative 1)



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.1 – General Arrangement

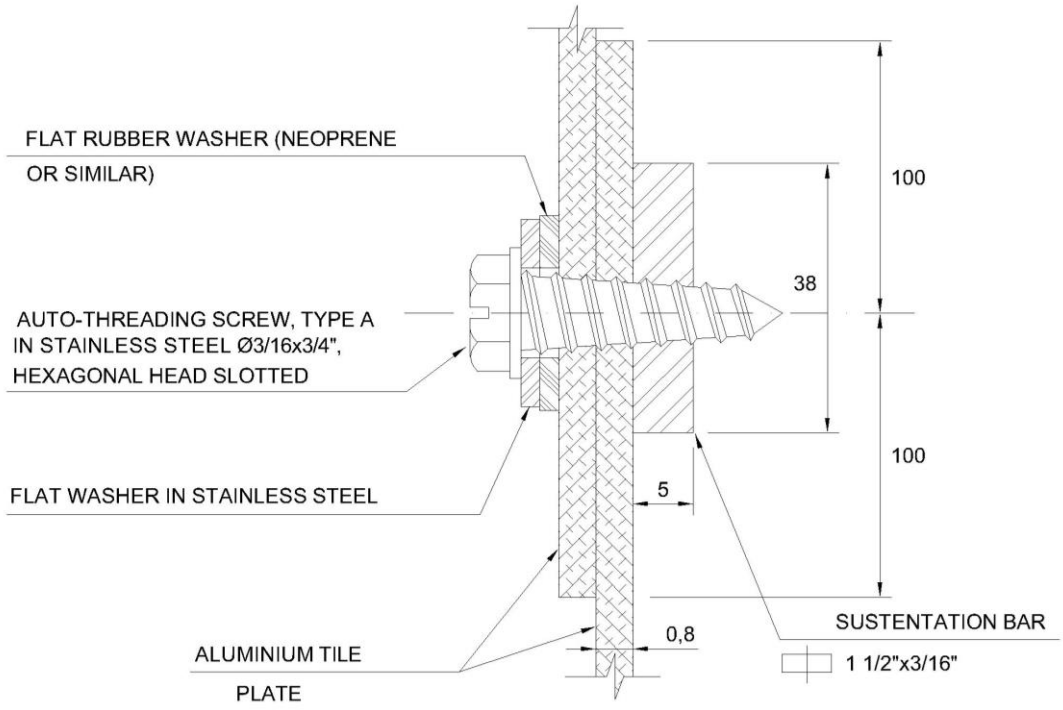
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



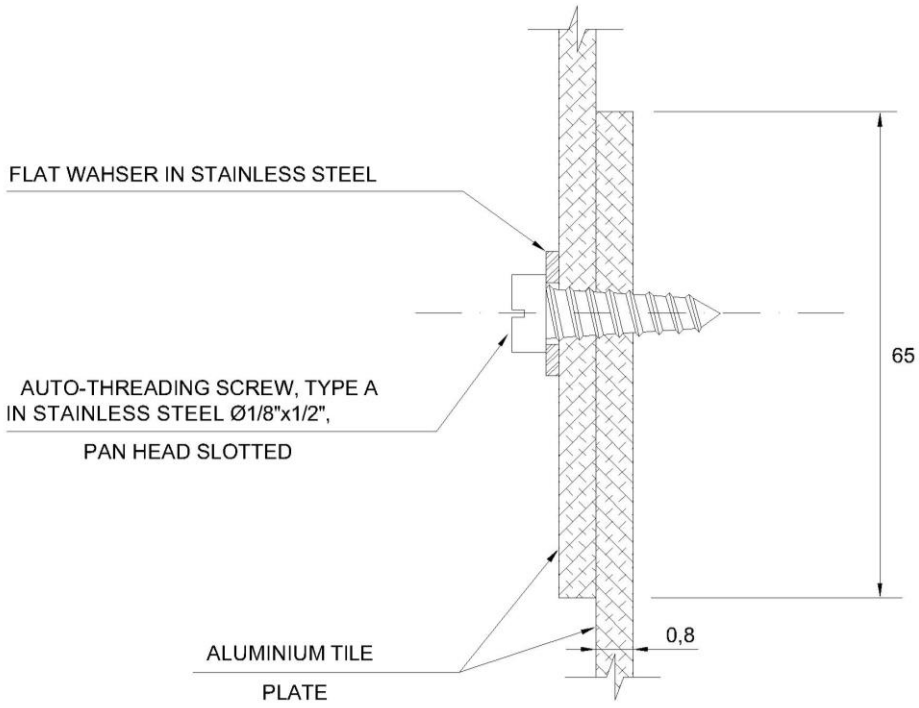
NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.2 - Typical Front View for Overlapping of Aluminum Tiles

Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



FIXATION OF ALUMINIUM TILES IN SUSTENTATION BARS IN CIRCUNFERENCIAL OVERLAPS

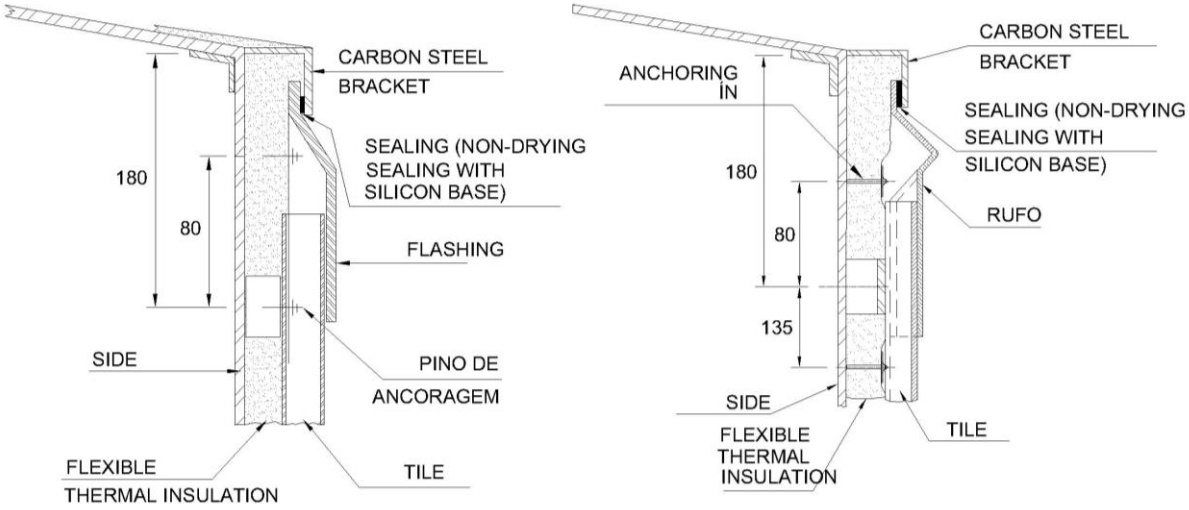


FIXATION BETWEEN ALUMINIUM TILES IN LONGITUDINAL OVERLAPS

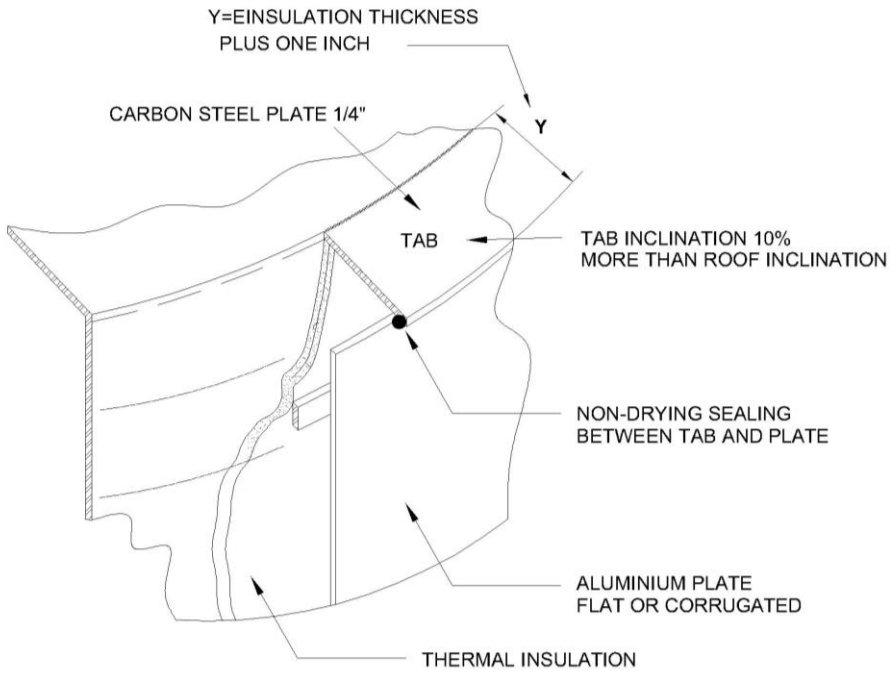
NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.3 – Aluminum Tile Attachment Details

Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



TYPICAL FLASHING DETAILS (ROOF WITH OR WITHOUT THERMAL INSULATION)

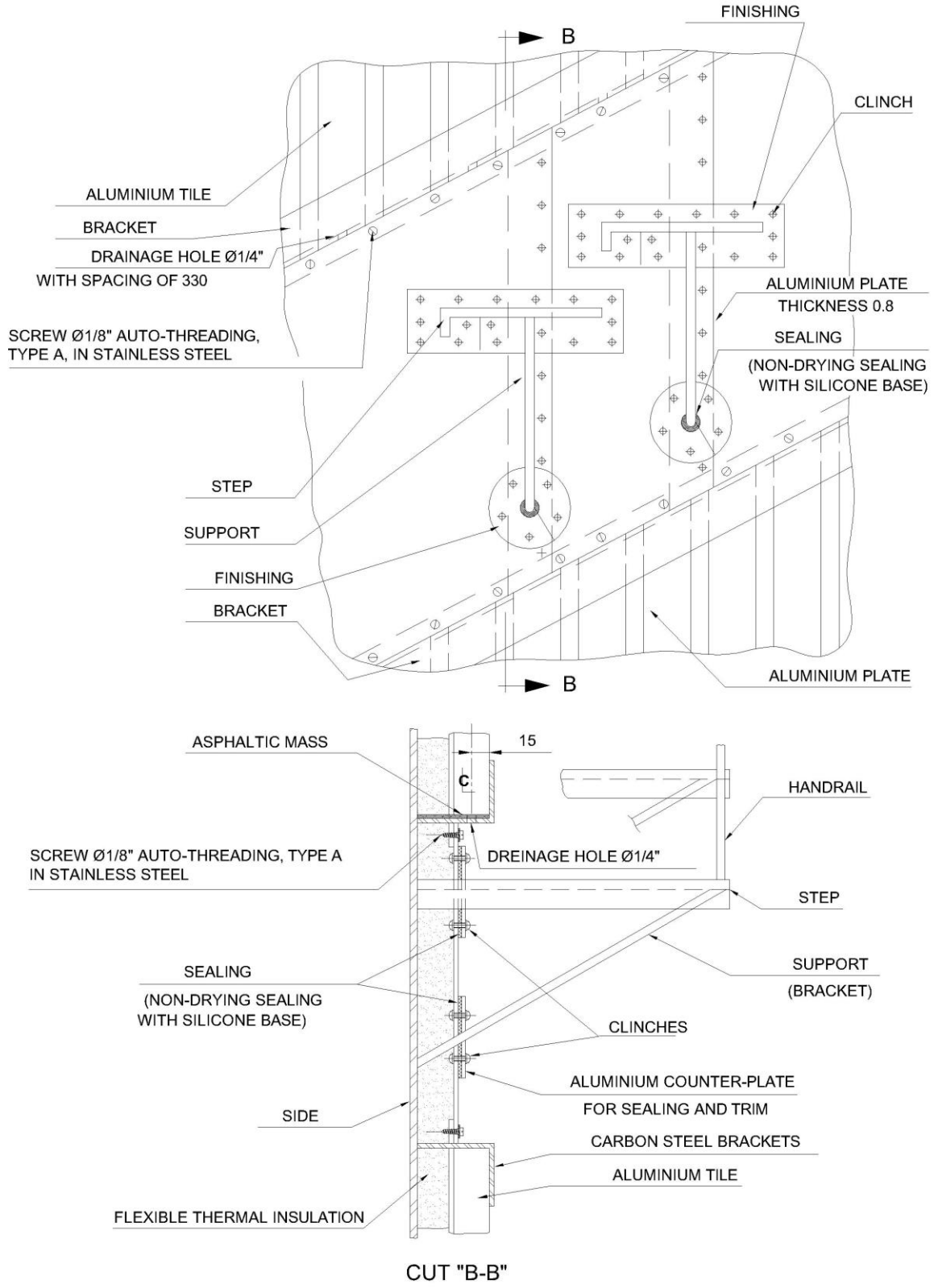


TYPICAL TAB DETAIL FOR ROOF WITHOUT THERMAL INSULATION

NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.4 – Assembly Details in the Region of Ruff

Figure A-18 - Thermal Insulation for Tanks (Alternative 2)

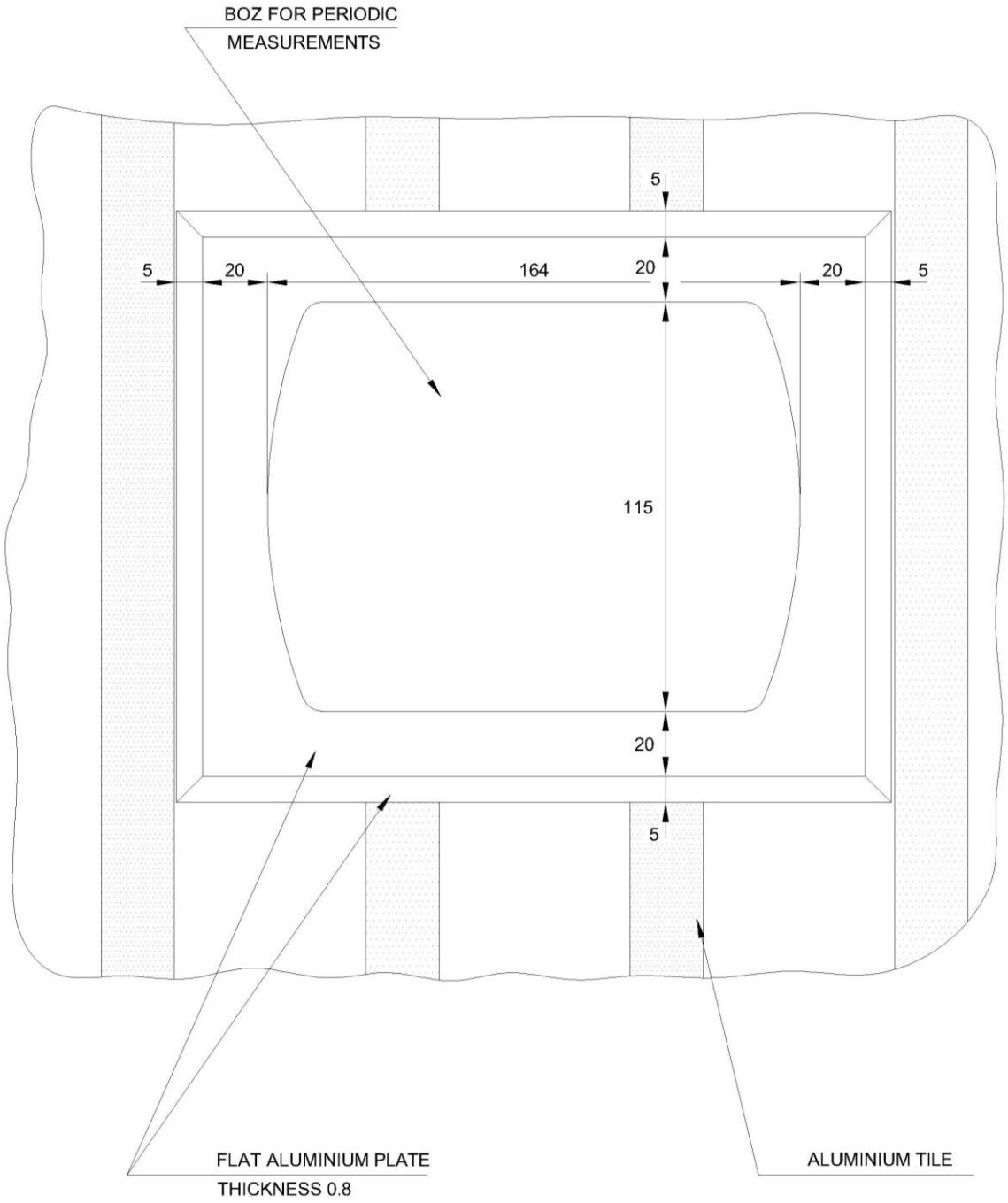


CUT "B-B"

NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.5 – Details of Insulation in Stairway Region

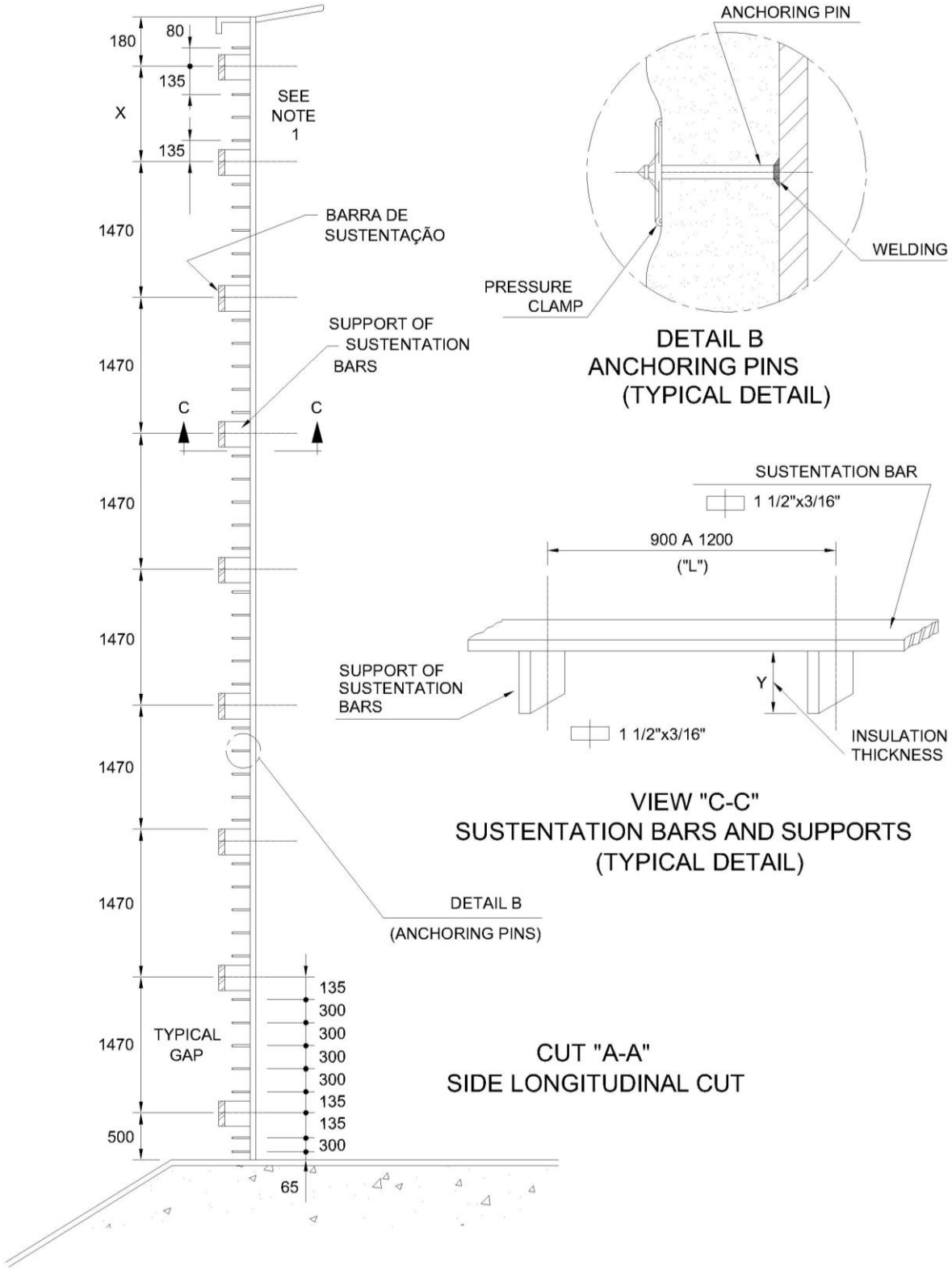
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.6 – Installation Details of Periodic Measurement Box

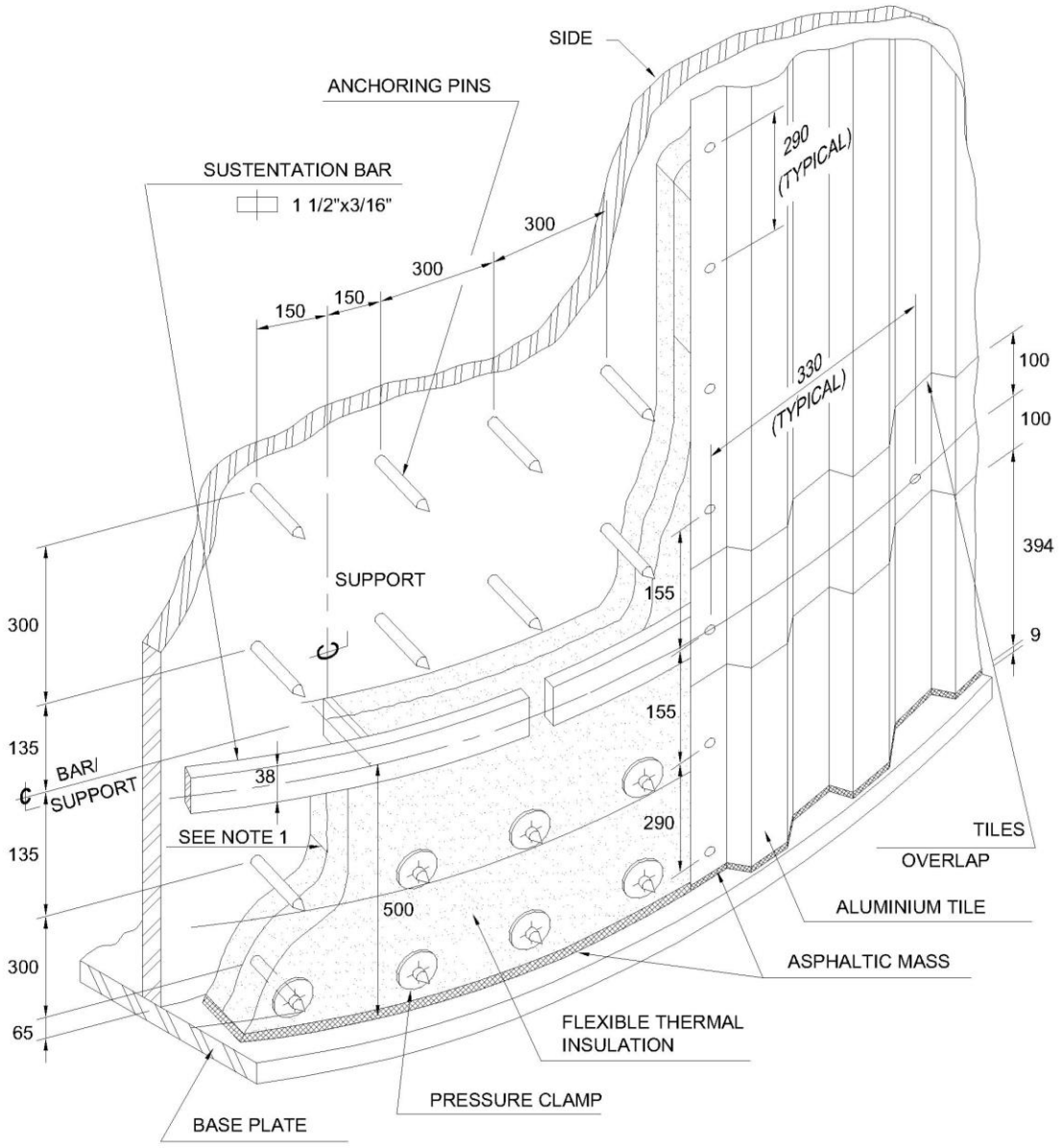
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



NOTES: 1) TO BE ADJUSTED DUE TO TANK HEIGHT.
2) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.7 - Distribution of Supporting Bars and Anchor Pins in Longitudinal Direction

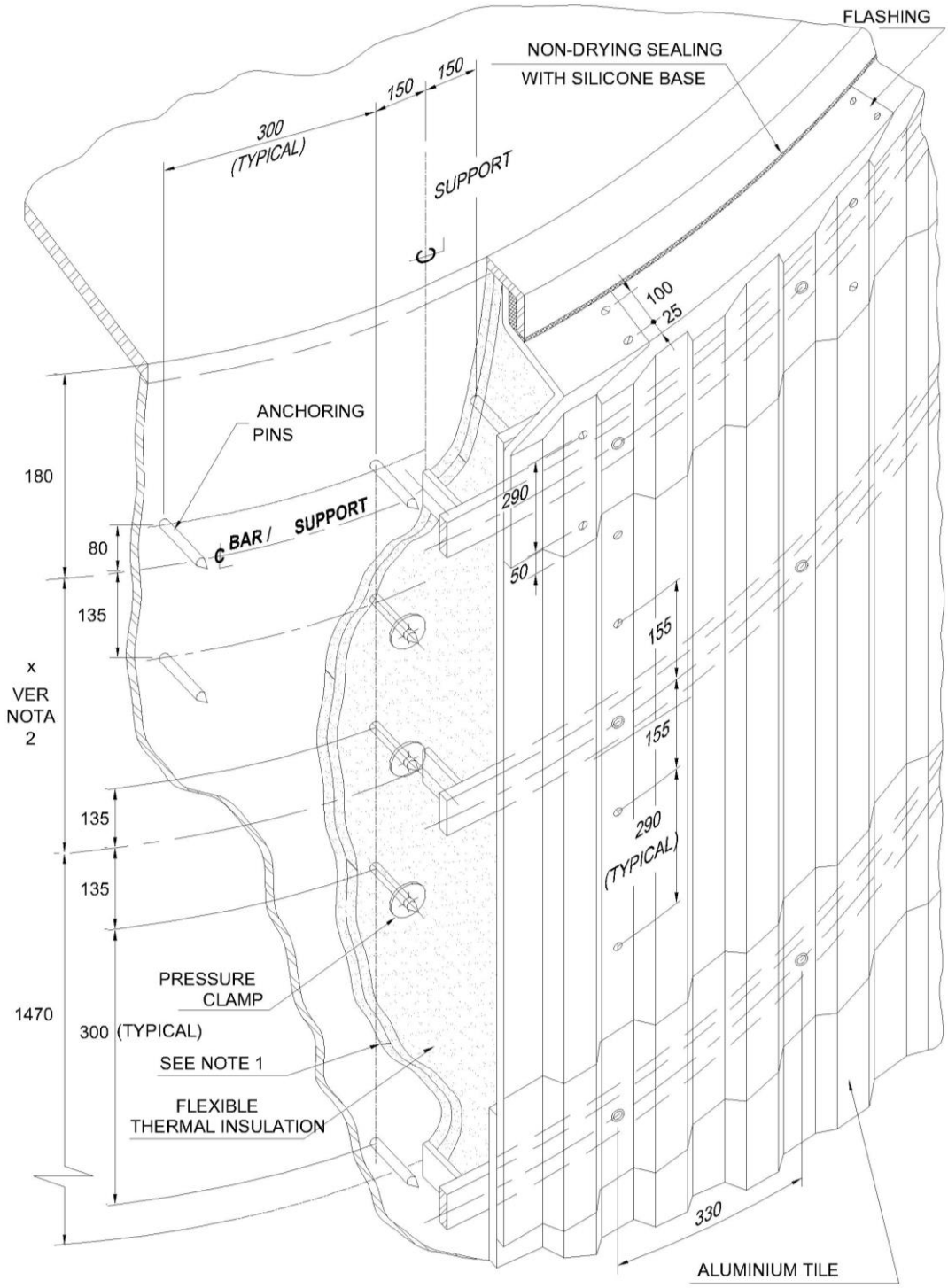
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



NOTES: 1) INSULATION PLATES CORRECTIONS SHALL BE ALWAYS SEPARATED, IF MORE THAN ONE INSULATION LAYER IS USED.
2) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.8 – Details of Installation on Tank Base

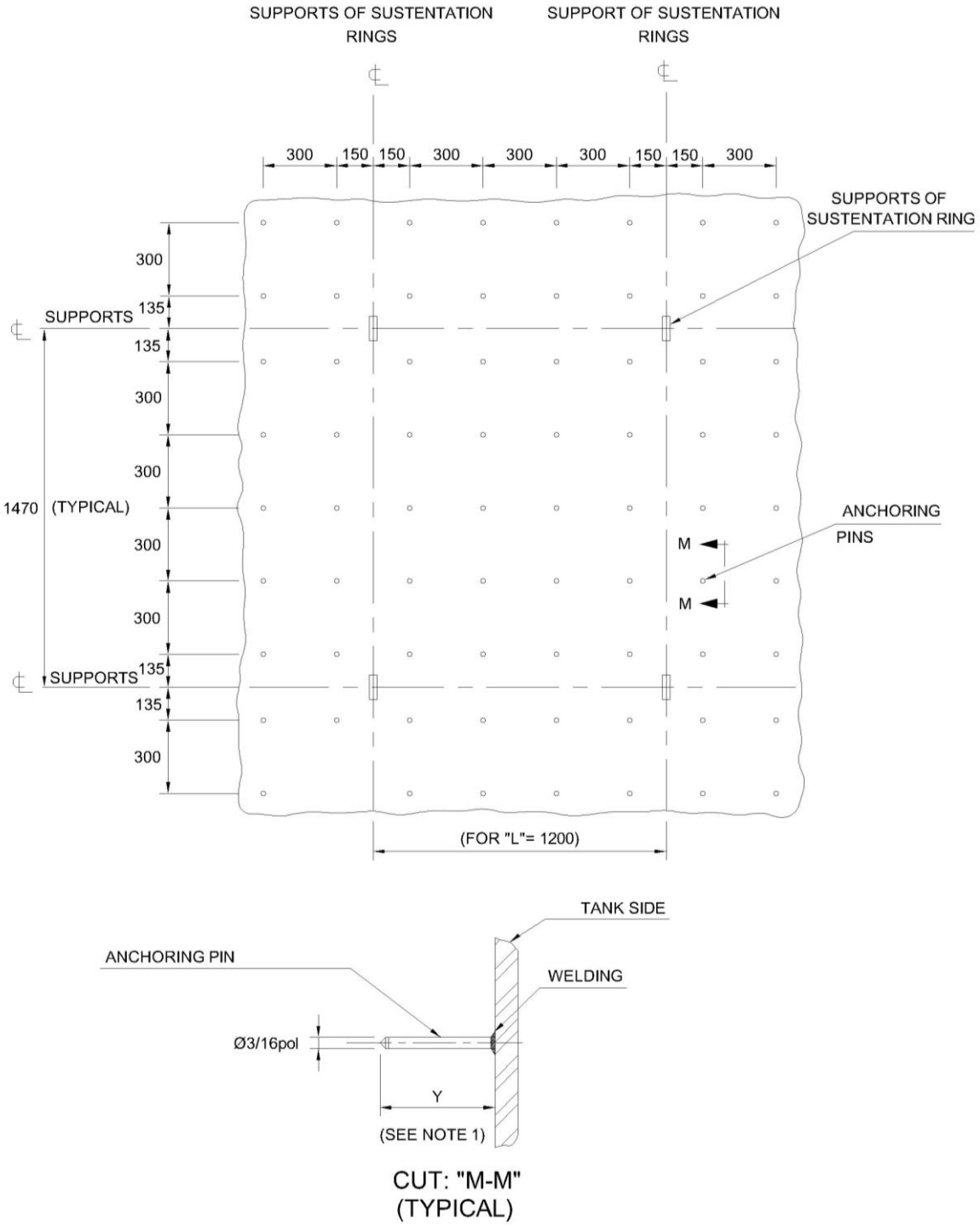
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



NOTES: 1) INSULATION PLATES CORRECTIONS SHALL BE ALWAYS SEPARATED, IF MORE THAN ONE INSULATION LAYER IS USED.
2) TO BE ADJUSTED DUE TO TANK HEIGHT.
3) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

Figure A-18.9 - Details of Assembly on Upper Part

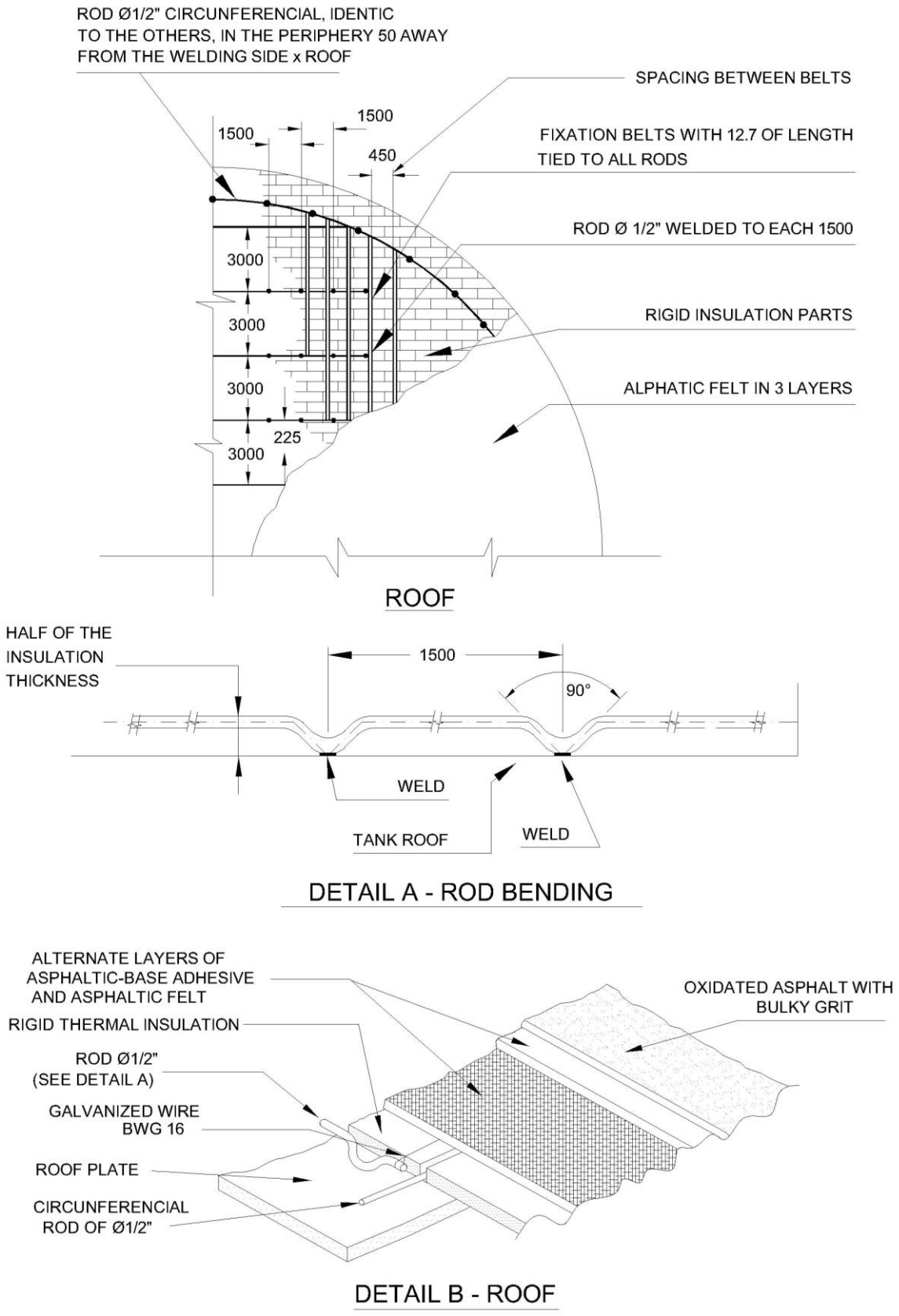
Figure A-18 - Thermal Insulation for Tanks (Alternative 2)



NOTES: 1) EQUAL TO THE THICKNESS OF USED THERMAL INSULATION.
2) DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

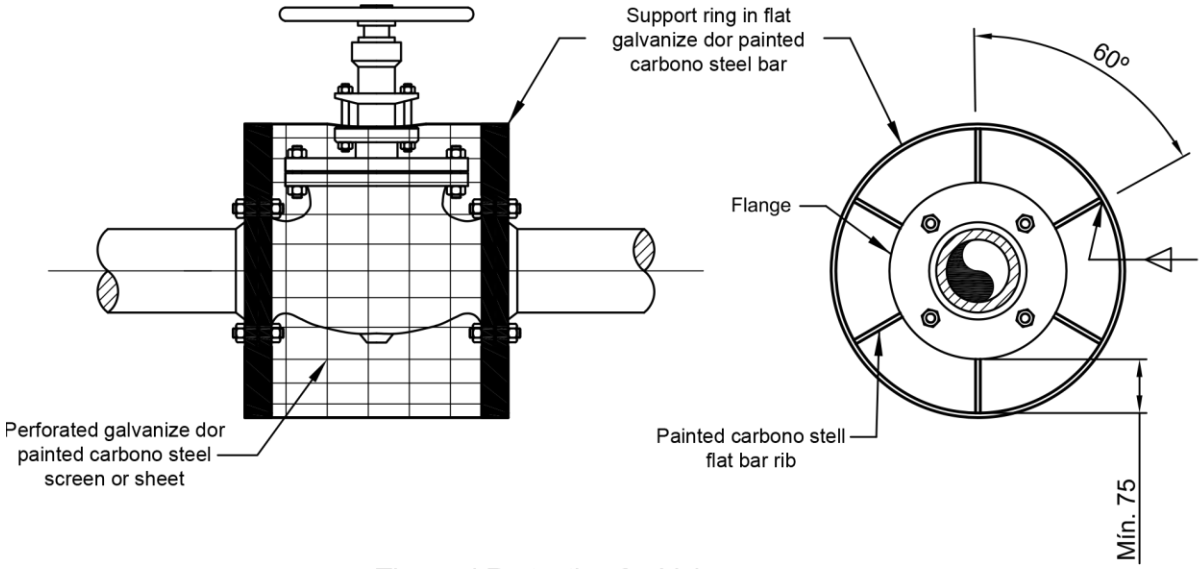
Figure A-18.10 - Typical Distribution of Anchor Pins in Relation to Supports of Supporting Bars

Figure A-18 - Thermal Insulation for Tanks (Alternative 2)

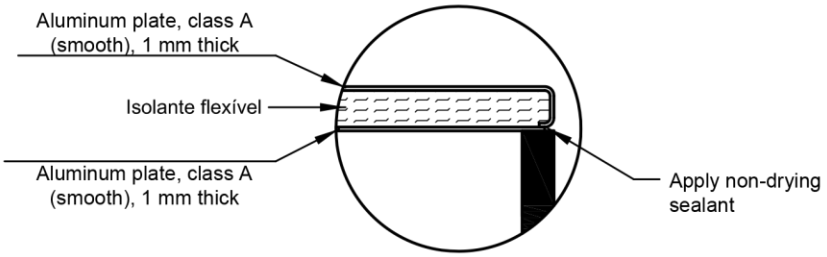


NOTE: DIMENSIONS IN MILLIMETERS, EXCEPT IF INDICATED OTHERWISE.

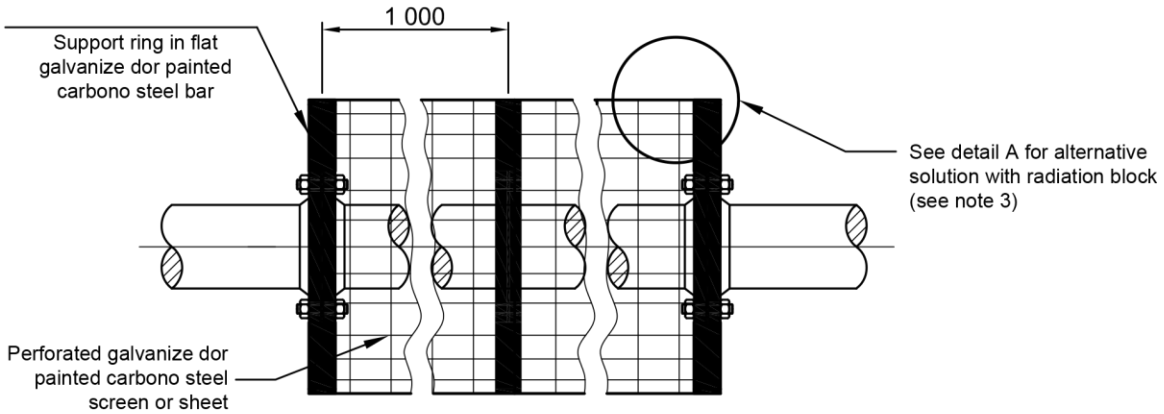
Figure A-19 - Thermal Insulation for Tank Roof



Thermal Protection for Valves



Detail A



Thermal Protection for Piping and Horizontal Vessels

NOTE 1 Dimensions in millimeters, unless otherwise specified.
NOTE 2 When the screen, plate, supports or ribs of the protection are painted, it shall comply with the painting conditions for pipes o equipment not insulated.
NOTE 3 If radiation block is necessary, it is recommended to replace the perforated screen or plate with insulation as per detail A.

Figure A-20 - Physical Barriers for Personal Protection

INDEX OF REVISIONS	
REV. A, B, C, D, E, F e G	
There is no index of revisions	
REV. H	
Affected Parts	**Description of Alteration**
All	Revised
REV. J	
Affected Parts	**Description of Alteration**
All	All parts revised