

**N-0896****REV. F****ENGLISH****04 / 2016****CONTEC**Comissão de Normalização  
Técnica**SC-09**Thermal Insulation and  
Refractories**Installation of Cold Insulation**

Revalidation

Revalidated in 04/2022.

## Installation of Cold 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.

***"The present Standard is the exclusive property of PETRÓLEO BRASILEIRO S.A. - PETROBRAS, for internal use in the Company, and any reproduction for external use or disclosure, without previous and express authorization from the owner, will imply an unlawful act pursuant to the relevant legislation through which the applicable responsibilities shall be imputed. External circulation shall be regulated by a specific clause of Secrecy and Confidentiality pursuant to the terms of intellectual and industrial property law."***

## CONTEC

Comissão de Normalização  
Técnica

## SC - 09

Thermal Insulation and  
Refractories

### Introduction

*PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting specialized of Technical Collaborators from Company and its Subsidiaries), are commented by Company Units and its Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of technicians from the same specialty, representing the various Company Units and its Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the Company Units and its 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 Technical Standard [N-1](#). For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.*

## Summary

Foreword.....	5
1 Scope.....	5
2 Normative References.....	5
3 Terms and Definitions.....	5
4 General Conditions.....	6
5 Pre-Molded Insulating.....	10
5.1 Piping - Straight Section.....	10
5.2 Piping - Curved Section and Accessories .....	11
5.3 Lids and Skirts of Vessel and Roundish Lid of Heat Exchangers .....	12
5.4 Input/Output Equipment Connection, Manholes and Instrument Connections .....	13
5.5 Horizontal Cylindrical Vessel and Heat Exchanger - Shell .....	14
5.6 Vertical Cylinder Vessel - Shell.....	14
6 Designed Polyurethane Insulating (Pulverization).....	15
6.1 Spheres, Lids and Shell of Horizontal and Vertical Cylindrical Vessel and Heat Exchanger.....	15
6.2 Equipment Input/Output connections, Manholes and Instrument Connections .....	16
6.3 Cylindrical Vertical Tank.....	16
7 Injected Polyurethane Insulation .....	18
7.1 Piping - Straight Section.....	18
7.2 Piping - Curved Section and Accessories .....	20
7.3 Cylindrical Vertical Tank - with Removal of the Forms .....	20
8 Qualification and Inspection .....	21
8.1 Pre-Molded Insulating .....	21
8.2 Insulating of Designed Polyurethane (Pulverization) .....	21
8.3 Insulating of Injected Polyurethane .....	22
8.4 Operation Inspection .....	23
9 Acceptance and Rejection.....	23
9.1 Pre-Molded Insulating.....	24
9.2 Insulating of Designed Polyurethane (Pulverization).....	25
9.3 Insulating of Injected Polyurethane.....	26
10 Procedures to Repair the Insulation .....	26
Annex A - Figures .....	27

## Figures

Figure A.1 - Layout of Pre-Molded Insulation Parts .....	27
Figure A.2 - Typical Insulation of Flanged Curves and Expansion Joints .....	28
Figure A.3 - Fixture of Insulating Parts in Piping (Single Layer or Last External) .....	29
Figure A.4 - Finishing of the Ends of Insulating Layers.....	30
Figure A.5 - Insulation of Interference Part Linked to the Piping.....	31
Figure A.6 - Fixture of the Protection Sheets .....	32
Figure A.7 - Typical Insulation of Curves and Connections .....	33
Figure A.8 - Insulation of Flanges .....	34
Figure A.9 - Insulation of Valves .....	35
Figure A.10 - Fixture of the Pre-Molded Insulation in the Union Shell-Lid .....	36
Figure A.11 - Equipment Inlet/Outlet Connection or Instrument Connection .....	37
Figure A.12 - Insulation of Manholes.....	38
Figure A.13 - Insulation of Horizontal Vessels' Shell.....	39
Figure A.14 - Support and Support Rings of the Vertical Vessels Insulating.....	40
Figure A.15 - Contraction Joint Insulation in Vertical Vessels.....	41
Figure A.16 - Insulation of Vertical Vessels with and without Fireproof Protection .....	42
Figure A.17 - Insulation of Roundish Lid of Heat Exchangers .....	44
Figure A.18 - Insulation of Spool With Removable Lid of Heat Exchangers .....	45
Figure A.19 - Insulation of Piping Amendment.....	46
Figure A.20 - Insulated Pipe by Injection (Factory) .....	47
Figure A.21 - Insulated Pipe by Injection (Field) .....	48
Figure A.22 - Insulated Support .....	49
Figure A.23 - Insulation of Tanks.....	52
Figure A.24 - Insulation of Tanks.....	54
Figure A.24 - Insulation of Tanks (Continuation).....	55
Figure A.25 - Boxes for Periodic Measurements.....	56

**Tables**

Table 1 - Piping Accessories Protection Coating.....	10
Table 2 - Protective Coating of Pre-Molded.....	11
Table 3 - Protection Sheets Fixing.....	11
Table 4 - Protection Coating of Piping Accessories.....	12
Table 5 - Weather Protection of Lids and Roundish Lids of Equipment.....	13
Table 6 - Protective Coating of Piping and its Accessories.....	19

## Foreword

This Standard is the English version (issued in 04/2021) of PETROBRAS N-896 REV. F 12/2016. 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 sets forth the required conditions for installation of thermal insulation of piping and equipment operating at low temperatures using rigid or flexible insulations.

1.2 This Standard applies to projects started from the date of issuance as well as to 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 (including amendments).

PETROBRAS [N-2](#) - Revestimento Anticorrosivo de Equipamento Industrial;

PETROBRAS [N-133](#) - Soldagem;

PETROBRAS [N-250](#) - Montagem de Isolamento Térmico a Alta Temperatura;

PETROBRAS [N-442](#) - Revestimento Externo de Tubulação em Instalações Terrestres;

PETROBRAS [N-894](#) - Projeto de Isolamento Térmico a Baixa Temperatura;

PETROBRAS [N-1618](#) - Material para Isolamento Térmico;

PETROBRAS [N-2238](#) - Reparo de Revestimento Anticorrosivo Externo de Tubos;

PETROBRAS [N-2913](#) - Revestimentos Anticorrosivos para Tanque, Esfera e Cilindro de Armazenamento.

**NOTE** For documents referred in this Standard and for which only the Portuguese version is available, the PETROBRAS department that uses this Standard should be consulted for any information required for the specific application.

## 3 Terms and Definitions

For the purposes of this document, the terms and definitions given in PETROBRAS [N-894](#) and [N-1618](#) and the following apply.

### 3.1

#### **piping accessory**

generic designation of valves, vents, steam traps, tees, caps, flanges, coupling, reducers, nipples, elbows and bends

**3.2****vapour barrier**

waterproof layer, with function to prevent the penetration of humid vapours and resulting frost up inside the thermal insulation material

**3.3****interference part**

any metal part that juts out of the vapour barrier

**3.4****weather protection (and mechanical damage) or cover sheet**

external coating, whose function is preventing humidity penetration and mechanical damage to thermal insulation and vapour barrier

**4 General Conditions****4.1 Materials**

4.1.1 Specific thermal insulating materials shall be used for insulation at low temperatures. All materials used shall be in accordance with PETROBRAS [N-1618](#) and [N-894](#).

**4.2 Safety Requirements**

Manufacturers' guidelines shall be followed for safe and proper handling of thermal insulation materials at low temperatures, considering the healthy, safety and environmental aspects.

**4.3 Preparation and Qualification of the Application Procedure**

4.3.1 An application procedure shall be presented for any service of low temperature thermal insulation assembly.

4.3.2 The application procedure shall be qualified for the applications of polyurethane (PUR) by projection and injection process. For pre-molded insulation it's not necessary to present the procedure qualification.

4.3.2.1 For projection (pulverization) application purposes, the application procedure shall be qualified according to 8.2.1 and 9.2.1 and shall contain at least the following information:

- a) distance between spray gun and the sheet;
- b) operating pressure of the gun;
- c) ratio of mixture between the components of insulating material;
- d) application sequence with indication of thicknesses per layer and final insulating thickness;
- e) criteria and methods for controlling the quality of the insulating coating and constituent materials, as Sections 8 and 9.

4.3.2.2 For injection application purposes, the application procedure shall be qualified according to 8.3.1 and 9.3.1 and shall contain at least the following information:

- a) ratio between injection time and volume of empty space between the part to be insulated and the box;
- b) ratio of mixture between the components of insulating material;
- c) positioning and number of holes for injection and/or vent (except for tanks);
- d) operating pressure of the gun;
- e) criteria and methods for controlling the quality of the insulating coating and constituent materials, as Sections 8 and 9.

**NOTE** In the case of tanks, use an injection gun to make the application within the mold.

4.3.2.3 In the application made of pre-molded insulating, the execution procedure shall contain at least the following information:

- a) sequence of application detailing the conditions set forth in this Standard;
- b) insulating materials to be applied (type, format, manufacturer and commercial reference);
- c) accessory materials such as sealants, waterproofing materials, adhesives, straps, tissues, indicating characteristics, manufacturer and commercial reference;
- d) application method of sealants, waterproofing material and adhesives, including thickness control method;
- e) criteria and methods for controlling the quality of the insulating coating and constituent materials, as Sections 8 and 9.

4.4 The hydrostatic testing of piping, pressure vessels, heat exchangers and tanks (including test of vacuum breaker valve) shall be performed before the application of thermal insulation. In cases where this practice is not viable (for example: on joints of pipes insulated at shop), leave the regions to be inspected temporarily without insulation. **[Recommended Practice]**

4.5 All welds of devices used for attaching insulating material shall be performed in accordance with PETROBRAS [N-133](#) and the construction and installation standards for equipments and piping systems.

4.6 The surfaces to be insulated shall receive surface preparation and paint application in accordance with the conditions established in the following standards:

- a) PETROBRAS [N-2](#): for Industrial Equipment;
- b) PETROBRAS [N-442](#): for piping;
- c) PETROBRAS [N-2913](#): for tank, sphere, storage cylinder and pressure vessel.

**NOTE** Painted surfaces shall be free of oil residues, grease, moisture and other foreign materials when applying the insulating material.

4.7 It is recommended a minimum clearance of 100 mm between the external surface of the insulation and any adjacent surface. **[Recommended Practice]**

4.8 The technical recommendations and the manufacturer's instructions shall be taken into account, except when there are divergences among them and this standard.

4.9 When the insulation has been performed with pre-molded material in multiple coats, the thickness distribution shall be in accordance with Table 1 of PETROBRAS [N-894](#).

4.10 The accessories insulation shall be performed with the same material and thickness used for piping or equipment insulation to which they belong.



4.11 At the beginning of the insulating shall only be allowed after the drying time for recoating of the paint used to protect piping and equipment.

4.12 The injection services shall not be performed in piping or equipment that are in operation (low or high temperature).

4.13 Removal of insulation from equipment or piping operating at low temperature shall not be programmed when such equipment or piping system are subjected to moisture condensation. When insulation removal is absolutely necessary, these sections shall be previously covered, before the insulating, by polyethylene film from 0,10 mm to 0,15 mm thick.

NOTE At points of interest for inspection, boxes for periodic measurements shall be installed (as Figures A.25 and A.25.1). **[Recommended Practice]**

4.14 During the insulating, it shall be provided protection against moisture until the vapour barrier is applied.

4.14.1 The vapour barrier shall be applied, preferably, during the same workday of insulating.

4.14.2 Protection from weather and mechanical damage shall be applied as soon as possible after drying the vapour barrier.

4.15 The weather conditions shall comply with the requirements defined below, when applying the insulating by projection or injection process:

- a) relative humidity below 85 %;
- b) room temperature up to 10 °C;
- c) wind speed less than 9 km/h (valid only for projection application);
- d) piping temperature or equipment between 20 °C and 50 °C.

NOTE It is permissible to use shields to suit the conditions described in this subsection.

4.16 The polyurethane injection services shall use warm equipment and hoses, mainly in cold places.

4.17 The pre-molded insulating parts shall be free of defects, such as edges, grooves or damaged ends.

4.18 The pre-molded insulating parts shall be adequately prepared to conform to the application surfaces, as well as to adjacent parts.

4.19 Every interfering part shall be insulated with a thickness equal to the insulating of the equipment or piping extending from a length equal to four times the thickness of the insulating or at least 300 mm (see Figure A.5).

4.19.1 The vapor barrier and the Interference parts shall be sealed in the part of contact with the interference part, applying not dryable sealant based in silicone rubber with neutral cure, to prevent moisture penetration in the insulation (see Figure A.5).

4.19.2 Parts of the interference metal type supports for piping, ladders or platforms shall have an intermediate position in the insertion of a block of non-metallic material and low thermal conductivity, that shall be made of treated wood, polyurethane/polyisocyanurate of density equal to or greater than 150 kg/m<sup>3</sup> or in high density engineering plastic (see Figures A.22, A.22.1 and A.22.2).

4.20 When piping or equipment have been submitted to high and low temperatures, a coat of rigid thermal insulation for high temperature shall be used firstly, or a suitable insulation material shall be selected for service at the established temperature range, according to requirements established in PETROBRAS [N-894](#).

**NOTE** When the thermal insulating selection is not suitable for high temperature services, according to 4.20, the steam-out operation shall not be performed, in order to preserv the thermal insulation. In this case, shall be used inert gases at room temperature.

4.21 For the purposes of this Standard, the waterproofing material, the adhesive and the dryable sealant may be the same product.

4.22 The fastening of the fixing straps shall be done by means of seals (see Figure A.2 of PETROBRAS [N-250](#)), so that there is a minimum free length of 25 mm. On each side of the seal there should be a 100 mm overlap of the strap for future tightening.

4.23 Near to flanges, valves, nozzles, legs, among others, the ending of insulation shall receive waterproofing, according to Figure A.4. The waterproofing shall be done according to the following sequence:

- a) make cut (bevel) at 45° at the end of insulation;
- b) apply a vapour barrier on the joint over the cut at 45°, extending to 50 mm for each side;
- c) apply the main vapour barrier covering the barrier applied on the joint over the cut at 45° to the end;
- d) mount weather damages protection.

**NOTE** In the case of flanges, the insulation material shall terminate at a distance from the flange equal to 1,5 times the length of the flange bolt.

#### 4.24 Vapour Barrier

4.24.1 It shall be composed of elastomeric aluminized asphalt blanket and self-adhesive, 3 mm thick.

4.24.2 In parts of interference, accessories and equipment of irregular geometry where it is not possible to apply the elastomeric asphalt blanket, it is accepted the option of vapour barrier consisting of two layers of asphalt or elastomeric base waterproof, streaky with fiberglass tissue, 3 mm thick.

4.24.3 Any damage observed after the installation of vapour barrier shall be immediately corrected.

4.24.4 When the coating of the last insulating layer presents porous or irregular display, so that it does not allow the adhesion of the vapour barrier, it shall be applied an asphalt base paint on the insulation before installing the vapour barrier.

#### 4.25 Weather Protection

4.25.1 The longitudinal and circumferential overlaps of the weather protection sheet shall be at least 50 mm and arranged in such a way as to avoid water infiltration.

4.25.2 The attaching of weather protection shall not damage the vapour barrier.

4.25.3 The sections of buried piping shall have weather protection or vapour barrier (when injected) coated with anticorrosive tape (according to PETROBRAS [N-2238](#)) throughout its length.

4.25.4 Class A aluminum protection sheets (flat sheet), when used, must be properly mangled and beaded on the longitudinal and circumferential edges (see Figure A.6 of PETROBRAS [N-250](#)).

### 5 Pre-Molded Insulating

#### 5.1 Piping - Straight Section

5.1.1 The first insulating layer shall be applied directly over the pipe and the subsequent layers shall be applied on a continuous layer of dryable sealant or waterproof of elastomeric or asphalt base.

5.1.2 The longitudinal and semi-circumferential joints shall be grouted with dryable sealant or waterproofing elastomeric or asphalt base.

5.1.3 The longitudinal joints shall be lagged by 90° (or half the width, in the case of sheets or segments), according to Figure A.1.

5.1.4 Semi-circumferential joints of insulating parts of odd layers shall not meet the length equal to half the length of the part and the even layers, a length equal to one fourth of the length of the part of the previous layer, according to Figure A.1.

5.1.5 Contraction joints shall be considered every 25 m of piping length, as shown in Figure A.2.

**NOTE** The existence of flange or valve along the piping sections replaces the contraction joint.

5.1.6 The fixing of the last or unique layer of pre-molded insulation shall be performed by filamentous tape and on the tape there shall be applied galvanized carbon steel wire for or stainless steel strap, 50 mm away from the ends of each parts (see Figure A.3), selected according to the pipe diameter, as per Table 1.

**NOTE** In multi-layer insulation, the inner layers shall be fixed only by means of filamentous tape.

**Table 1 – Pré-molded Insulation Materials Layers Fixing**

Piping Nominal Diameter NPS	Fixing
$\varnothing \leq 12"$	$\varnothing 1,65$ mm Galvanized carbon steel wire or higher
$\varnothing > 12"$	12,7 mm (1/2") Stainless steel strap

5.1.7 The external surface of the last layer of insulating shall receive a vapour barrier.

5.1.8 The weather protection of insulation material shall be performed according to Table 2.

NOTE In regions subject to hailstorm, it is recommended not to use aluminum foil 0.15 mm thick.  
[Recommended Practice]

**Table 2 – Coating for Protection of Pre-Molded**

Protection Coating	Thickness (mm)	Nominal Diameter of Piping NPS
Corrugated Aluminum Class B Type II	0,15	Ø ≤ 12"
	0,40	Ø > 12"
Flat Aluminum Class A Type II	0,50	Ø ≤ 12"
	0,80	Ø > 12"

5.1.8.1 In vertical sections or with slope higher than 45°, the top sheet shall overlap the lower one, and "S" clips shall be installed, to support the sheets, spaced at 300 mm, using at least two clips lagged by 180° (see Figure A.6).

5.1.8.2 The longitudinal overlap shall always be located so as to prevent water penetration.

5.1.8.3 The fixing of corrugated protection sheets (see Figure A.6) shall be made with straps according to Table 3 as follows:

- a) fix a strap in the middle of each circumferential overlap;
- b) intercalate two other straps between the others fixed on the overlays.

NOTE The start and end sheets of the coating shall receive a strap 25 mm from the end of the coating (see Figure A.7).

**Table 3 – Fixing of Corrugated Protection Sheets**

Nominal Diameter of Piping NPS	Fixing
Ø ≤ 12"	Aluminum Strap of 12,7 mm (1/2")
Ø > 12"	Stainless Steel Strap of 12,7 mm (1/2")

5.1.9 In the case of buried piping, see also 4.25.3.

## **5.2 Piping - Curved Section and Accessories**

5.2.1 In insulation of curved parts, tees or reducers, shall be cutted and applied the same material used for the piping, keeping the geometry of accessorie ( see Figure A.2 for flanged curves and the Figure A.7 for the other accessories).

5.2.2 The insulating application shall comply with 5.1.1, 5.1.2, 5.1.3 and 5.1.6.

5.2.3 In flanges and valves (see Figures A.8 and A.9, respectively) the insulation shall overlap the piping insulation from a length equal to the thickness of the piping insulation.

NOTE 1 The valves shall be insulated to the level of the gasket (see Figure A.9).

NOTE 2 For temperatures lower than -70 °C, shall be forecasted an removable insulating for rod and steering wheel that allows its removal and reassembly for manual operation of the valve.

5.2.4 Piping supports shall be insulated as shown in Figure A.22.

5.2.5 The vapour barrier shall be installed in accordance with 4.24.

5.2.6 Weather and mechanical damage protection of piping accessories shall follow the provisions in Table 4.

NOTE The fixing of the protection coating on the sheets of the accessories of the piping coating shall be made in the circumferential overlapping through self-tapping screws, 90° distant for pipes whose nominal diameter is up to 8" and 45° for larger diameters and sealed with not dryable sealant.

**Table 4 - Piping Accessories Protection Coating**

Protection coating	Thickness (mm)	Nominal diameter of piping NPS
<b>Aluminum sheet class A Type II (smooth, no barrier)</b>	0,5	$\varnothing \leq 8"$
	0,8	$8" < \varnothing \leq 24"$
	1,0	$\varnothing > 24"$
<b>Zinc and pre-painted carbon steel sheet</b>	0,3	$\varnothing \leq 8"$
	0,5	$\varnothing > 8"$
<b>Stainless steel sheet</b>	0,3	$\varnothing \leq 8"$
	0,5	$\varnothing > 8"$

### 5.3 Lids and Skirts of Vessel and Roundish Lid of Heat Exchangers

5.3.1 The application of insulating parts on the surface to be insulated shall be initiated towards the top until the bottom of the equipment.

5.3.2 The first layer of insulating shall be fixed applying, by points, an asphalt or elastomeric base adhesive in the part, to fix it on the surface of the equipment until the placement of straps.

5.3.3 The top joints shall be diverging from a length equal to half the length or width of the insulating part and, except for the first layer, grouted with dryable sealant.

5.3.4 Straps and seals shall be of stainless steel 12,7 mm in width, placed on a filamentous adhesive.

5.3.5 Apply elastomeric or asphalt base waterproofing with a humid thickness of 3 mm, completely covering the external surface of the first insulating layer, including assembly straps and stamps, with no bubbles or craters.

5.3.6 Apply a second layer of insulation on the waterproof coating mentioned in 5.3.5, while the coating is still humid, thus fixing the second insulating layer.

5.3.7 The grouting of top joints shall be done with dryable sealant, constituting a complete sealing of all joints of the insulating part.

5.3.8 The anchorage of other layers shall follow the same procedure mentioned in 5.3.4, 5.3.5 and 5.3.6, and the external surface of the last insulating layer shall receive a vapour barrier in accordance with 4.24.

5.3.9 The joint of the lid insulating with the side one, of vertical or horizontal cylindrical vessels, shall be done according to Figure A.10.

5.3.10 In the lids of pressure vessels and heat exchangers, there shall be applied over the vapour barrier a weather and mechanical damage protection, in accordance with Table 5.

**Table 5 - Weather Protection of Lids and Roundish Lids of Equipment**

<b>Weather protection</b>	<b>Thickness (mm)</b>
<b>Aluminum sheet class A Type II (smooth, no barrier)</b>	1,0
<b>Zinc and pre-painted carbon steel sheet</b>	0,5
<b>Stainless steel sheet</b>	0,5

5.3.11 Insulation of exchanger lids shall comply with the provisions in Figures A.17 and A.18.

5.3.12 Insulation of lower lids and skirts shall comply with the provisions in Figures A.16 and A.16.1.

#### **5.4 Input/Output Equipment Connection, Manholes and Instrument Connections**

5.4.1 They shall be insulated as Figures A.11 and A.12.

5.4.2 The removable insulation coverage shall be fixed on the external surface of the equipment's insulation layer, after applying the equipment's vapour barrier. The vapour barrier from the removable shall overlap the equipment's vapour barrier in 50 mm.

5.4.2.1 The various component parts of the removable coverage shall be join with asphalt base or elastomeric adhesive and the gaps shall be filled with flakes of fiberglass.

5.4.2.2 The removable cover shall be concentric in relation to the connection or manhole to be insulated.

5.4.3 Apply weather and mechanical damage protection in accordance with 5.3.10, with 100 mm of extension of the barrier under the cover sheet of the equipment and sealed with not dryable sealant.

## **5.5 Horizontal Cylindrical Vessel and Heat Exchanger - Shell**

5.5.1 Application of insulation shall follow the requirements described in 5.3.1 to 5.3.8.

5.5.2 The insulating parts shall be fixed by filamentous adhesive tape and on the tape there shall be applied a stainless steel strap 12.7 mm thick (see Figure A.13) 50 mm away from the ends of the insulating parts (circumferential joints). In multi-layer insulation, the inner layers shall be fixed only by means of filamentous adhesive. On each side of the seal, there shall be an overlap of 100 mm, for refasten.

5.5.3 Weather and mechanical damage protection shall be applied over a vapour barrier, made by applying a coating of corrugated aluminum sheet, class B, type II, 0,40 mm thick. This protection can also be on flat aluminum sheet, class A, type II, 0,8 mm thick.

5.5.3.1 The protective sheets shall be applied with an overlap of 75 mm, both circumferential and longitudinal (see Figure A.13).

5.5.3.2 The longitudinal overlap shall always be located in order to prevent water penetration.

5.5.3.3 The protection sheets shall be fixed by at least three stainless steel straps, each one on a circumferential overlap and the intermediate ones, with a maximum spacing of 530 mm. The width of the straps shall be 12,7 mm and they shall be fixed by stainless steel seals applied in the longitudinal overlapping region.

5.5.4 The input/output connections and vessel manholes, as well as instruments connections, shall follow the same procedure in 5.4.

## **5.6 Vertical Cylinder Vessel - Shell**

5.6.1 Application of insulation shall follow the requirements described in 5.3.1 to 5.3.8.

5.6.2 The support rings to the insulating shall have a maximum spacing of 8 000 mm. At the upper end of the equipment, the last ring shall start with a distance of 300 mm from the lid weld, and at the bottom one, with a 600 mm distance from the equipment's skirt weld (see Figure A.14). Reinforcement rings of the vessels shall be used as support rings.

5.6.3 Contraction joints shall be foreseen along the bottom part of the support rings, with a 25 mm width (see Figure A.15).

5.6.3.1 The contraction joint shall start on the tank surface and extend to the external surface of the last insulating layer (Figure A.15).

5.6.3.2 The area constituting the joint shall be filled with strips of elastomeric foam with a density of 60 kg/m<sup>3</sup> and 50 mm thick, compressed for a thickness of 25 mm (see Figure A.15).

5.6.3.3 The coverage of the joint shall be with the same insulating material of the insulation remainder, with a thickness equal to half the thickness of the vessel's insulation and with the overlap shown in Figure A.15.

5.6.3.4 The fixture of the contraction joint coverage of shall be made by means of stainless steel seals and straps 12.7 mm in width, applied 25 mm from the cover's high and low ends (see Figure A.15).

5.6.4 The vapour barrier applied over the insulation shall follow the same procedure 4.24.

5.6.5 The input/output connections and vessel manholes, as well as connections of instruments, shall follow the same procedure as 5.4.

5.6.6 The weather and mechanical damage protection should follow the same procedure 5.5.3 (see Figures A.16.1 and A.16.2).

5.6.6.1 The finishing of protection sheets, along the vessels skirts, shall be in accordance with Figures A.16.1 and A.16.2.

5.6.6.2 In the circumferential overlapping sheets of protection, "S" clips shall be used spaced at 600 mm, to assist in fixing the sheets (see Figures A.16.1 and A.16.2).

## **6 Designed Polyurethane Insulating (Pulverization)**

The using of the technique of designed polyurethane application shall attend the environmental restrictions, fitting critical analysis regarding the spread of particulate material in the air, because of the risk to hit equipment or facilities, causing irreversible damage to their paintings.

### **6.1 Spheres, Lids and Shell of Horizontal and Vertical Cylindrical Vessel and Heat Exchanger**

6.1.1 The following attention should be taken before and after application of insulating compound:

- a) isolate the peripheral area to equipment;
- b) place warning signs prohibiting smoking, welding and the approach of strangers to the service;
- c) protect the neighboring equipment against the effect of particles of the insulating compound that is being applied;
- d) completely remove the designed material not deposited on the surface to be insulated;
- e) size the equipment area to be insulated, so that the foam application and vapour barrier are carried out on the same workday;
- f) contain the solid waste spread from the normalization of the surface.

6.1.2 The application of insulating compound shall follow the procedure below:

- a) apply the insulating compound downward so that, after expansion, is between 10 mm and 25 mm thick;
- b) perform visual inspection of the applied layer;
- c) repeat the described in a) and b) until reach the total thickness of insulation;
- d) surface finish shall look like an "orange peel", and the maximum allowable ripple shall be 5 % of the total insulation thickness, determined by equipment's design. In case of additional thickness or large irregularity, regularize the external surface of expanded insulating by mechanical means such as scraping or sanding.



6.1.2.1 The application of the insulating compound shall be protected from wind, rain, dust and others.

6.1.2.2 The application shall be made by giving the gun a helical motion (rotation and uniform vertical advances) and making it pass into the chamber where it receives, by jet spray, a film which, after expansion, constitutes the thermal insulation.

6.1.2.3 The ends of the insulation shall be beveled to 45° and shall receive a protection, consisting of an impermeable elastomeric or asphalt base coating.

6.1.3 The vapour barrier applied over the insulation shall follow the same procedure as 4.24.

If it is not possible to complete the implementation of the vapour barrier in the same working day, the following guidelines shall be followed:

- a) protect, preferably, the insulated area on a working day, with a vapour barrier with a thickness of 50 % of the total value foreseen;
- b) 200 mm overlap at the vapour barriers in the regions of splicing of two days of work;
- c) implement the remaining 50 % of the vapour barrier thickness, after the end of the application work of all insulation.

**NOTE** If the vapour barrier has been designed to be in a single layer, the insulating protection without barrier shall be through fully waterproof tarpaulins to penetration of humidity from rain or air.

6.1.4 Weather and mechanical damage protection shall be performed as 5.5.3. In the case of lids, a weather and mechanical damage protection shall be placed, in accordance with 5.3.10.

## **6.2 Equipment Input/Output connections, Manholes and Instrument Connections**

The insulation shall follow the same procedure of 6.1, taking due care to protect the parts that should not be insulated.

## **6.3 Cylindrical Vertical Tank**

6.3.1 Use Figure A.23 as typical drawing of insulation installation.

6.3.2 The application of insulating shall follow the procedure below:

- a) master collage as 6.3.3;
- b) apply the insulating compound downward so that, after expansion, it is between 10 mm and 25 mm thick;
- c) perform visual inspection of the applied layer;
- d) repeat the described in b) and c) until the total thickness of insulation is reached;
- e) the surface finish shall look like an "orange peel" and the maximum allowable ripple shall be 5 % of the total insulation thickness, determined by equipment's design. In case of additional thickness or large irregularity, regularize the external surface of expanded insulating by mechanical means such as scraping or sanding.

6.3.3 The total thickness of the insulation shall be guided by the application in the field of masters with rectangular profile, base of 100 mm, height 10 mm less than the total thickness estimated for insulation and length of 1 000 mm.

6.3.3.1 The masters shall be manufactured as of molding in an open box, in polyurethane of same density and thermal conductivity of the insulation and cut down to an established size.

6.3.3.2 The masters shall be glued to the side of the equipment with proper insulating compound and immediately receive a layer of polyurethane designed to lock the cells of its outer surface exposed.

6.3.3.3 The masters form delimiters frame of the regions for polyurethane application, being fixed with vertical distance of 1 m to 2 m from each other, and from 2 m to 5 m of horizontal distance. The sizing for the distance between the masters shall be object of study guided by performance application of the insulating, aiming to meet the recommendation to install the vapour barrier in the same working day.

6.3.4 The projection of polyurethane shall be done from top to bottom.

6.3.5 The application of polyurethane shall be by a complete ring and not in vertical stripes.

6.3.6 A joint contraction shall be installed near the first ring, as follows:

- a) up to a height of 1 700 mm, applying a layer of glass wool panel with 25,4 mm thick and density of 40 kg/m<sup>3</sup>, with aluminum foil, and the seal of the joints between panels shall be made of filamentous tape 50 mm wide. This layer can also be of elastomeric foam of equal thickness;
- b) fix the panels on the circumference of the tank, with the sheet facing the outside, using four straps, of stainless steel AISI 304, 12,7 mm wide, with two on the ends and two intermediate ones, equally spaced from the bottom;
- c) the side anchoring bars (bolts) shall also be wrapped with fiberglass or elastomeric foam (contraction joint)
- d) apply the insulating compound over the entire board of contraction joint and anchor bars.

6.3.7 The top edge of the ceiling, made of a compression sheet, shall have in their entire circumference, a flat bar, of stainless steel AISI 304, 50,8 mm x 3,2 mm welded, which serves to fix the insulating ruff protector. See detail A of Figure A.23.1.

6.3.8 The application of insulating compound on the side shall allow install the ruff without damage in insulation, especially in the vapour barrier.

6.3.9 The tank accessories such as manholes, pipe connections and structural supports shall be insulated by adopting the injection system in a closed box, as provided in 7.2.

6.3.10 The control of the thickness of the insulation during the application of the insulating compound shall be performed by a method that does not puncture or damage the thickness of polyurethane.

6.3.11 The physical characteristics of polyurethane, ceased the chemical reactions and presenting stabilized, shall be evidenced by laboratory tests, whose frequency should be in the implementation procedure in accordance with 4.3.2.

6.3.12 The insulation fixture systems (for adherence), of the metal protection (rivets and straps) of the vapour barrier (for adherence), may not result in the welding of supports or anchors to the side of the tank, here regarded as cold spot that protrude out of the insulating thickness.

6.3.13 The vapour barrier should be applied as 4.24.

6.3.14 Assemble weather and mechanical damage protection over the vapour barrier, using smooth aluminum sheet, class A, type II 1,0 mm thick up to a height of 1 700 mm from the bottom of the tank. Exterior protection above 1 700 mm shall be fitted with aluminum tile, wavy type, with undulations positioned vertically and minimal overlap of 100 mm. The fixation between the sheets shall be obtained through hermetic rivets, spaced no more than 300 mm between one to another.

**NOTE** The overlap between the flat aluminum sheet and wavy tile shall have a junction ruff.

6.3.15 In the vicinity of the ceiling there shall be installed protective metal ruff, mixed type (plain/corrugated), using aluminum sheets of 1 120 mm x 300 mm x 300 mm wavy x 0,8 mm thick, fixed by hermetic rivets, spaced no more than 300 mm between one to another.

6.3.16 In the vicinity of the seating base of the tank, the protective sheet shall be fixed in bracket with equal edge on aluminum 38 mm x 38 mm x 3,2 mm thick, mounted entire circumference, and hermetically sealed at the seams for purposes of fixing the protective sheet.

6.3.17 The external protection may be mounted ring by ring from the base of the tank towards the ceiling, with lashing straps in stainless steel AISI 304, 19 mm in width, spaced vertically between 430 mm (minimum) and 450 mm (maximum) and having expanders of each 6 000 mm, and there shall be at least 4. The fixation between the sheets shall be made through the application of hermetic rivets, spaced no more than 300 mm between one to another.

**NOTE** The undulated tile shall be riveted on the undulation farther from insulation in order to preserve the vapour barrier.

6.3.18 The expanders shall be composed of double sine spring, stainless steel AISI 304.

6.3.19 Forecast horizontal and vertical overlap between undulated sheets of 100 mm, so as to prevent ingress of rain. Using "S" clips of the same material as the straps (see detail B of the Figure A.23.1).

6.3.20 The closing amendment of the lashing straps shall be made of stainless steel seal AISI 304.

## **7 Injected Polyurethane Insulation**

### **7.1 Piping - Straight Section**

7.1.1 The pipes to be coated shall follow the procedure below:

- a) cover the pipe to be insulated with PVC film or polyethylene thickness between 0,10 mm and 0,15 mm, coiled around the pipe in order to prevent the adhesion of the insulating to the substrate and the free movement due to retraction of both the pipe and the insulating material;
- b) fix by means of adhesive or filamentous tape and galvanized wire, center rings of expanded polyurethane (minimum specific mass 55 kg/m<sup>3</sup>) at intervals of 1 000 mm, and the two ends are fixed at 150 mm from the tips or the end of the thread of the pipe (see Figure A.20), to allow the execution of welds or threaded coupling; if flanged, fixing at length of 1,5 times the length of the flange screw, in order to enable its assembly;

- c) introduce a PVC pipe liner with a minimum thickness of 1 mm or metal sheet (see 7.1.2), supporting him in the center rings;

**NOTE** The PVC pipe liner should only be used in piping (outside industrial unit) or underground piping.

- d) perform two 16 mm holes near each side of the center rings, assuming other holes in order to ensure the perfect filling of the liner;
- e) cover the external areas near the holes with a release agent in order to facilitate removal of the foam after injection;
- f) inject polyurethane foam;
- g) plugging the holes when the foam begins to spill;
- h) apply, on the external sides of the extremes rings, a waterproof layer as 4.24;
- i) in the case of underground piping, see 4.25.3.

7.1.2 If the liner is used in metal sheet, in addition to 7.1.1 it shall follow the procedure below (see Figure A.21):

- a) the metal sheets to liner shall be in accordance with Table 6;
- b) using overlapping 50 mm in longitudinal and circumferential amendments;
- c) in vertical sections parts the top liner overlaps the bottom one;
- d) fix the protective liner by means of hermetic rivets, spaced no more than 150 mm in longitudinal and circumferential overlapping;
- e) apply not dryable sealant in areas of longitudinal and circumferential overlapping and rivets holes;
- f) after the injection and removal of spilled foam, the longitudinal and circumferential amendments of protective liners should be given to its fullest extent, a continuous seal of self-adhesive aluminum tape, 50 mm in width.

**Table 6 - Protective Coating of Piping and its Accessories**

Protection coating	Thickness (mm)	Nominal diameter of piping $\varnothing$ (in)
Aluminum sheet class A type II (smooth, no barrier)	0,8	$\varnothing \leq 24"$
	1,0	$\varnothing > 24"$
Zinc and pre-painted carbon steel sheet	0,3	$\varnothing \leq 8"$
	0,5	$\varnothing > 8"$
Stainless steel sheet	0,3	$\varnothing \leq 8"$
	0,5	$\varnothing > 8"$

7.1.3 After the pipes linkage, and meeting 4.4 and 4.6, making joints insulation in accordance with the following procedure (see Figure A.19):

- a) cover the pipe to be insulated with PVC film or polyethylene between 0,10 mm and 0,15 mm thick, coiled around the pipe, in order to prevent the adhesion of the insulating to the substrate and the free movement due to retraction of both, the pipe and the insulating material;
- b) apply on the joint a removable mold and inside the mold, a demolding agent;
- c) inject foam through a hole made in the mold;
- d) remove the mold after the expansion of the insulating liquid;
- e) apply a vapour barrier according to 4.24, overlapping the pipe liner in 50 mm;
- f) apply the protective coating in the region of the amendment in accordance with Table 6, overlapping the coating on the pipe liner in 100 mm on each side, applying not dryable sealant and fixing the coating with straps and seals;
- g) in the case of underground piping, see also 4.25.3.

## **7.2 Piping - Curved Section and Accessories**

7.2.1 The insulation shall follow the procedure of 7.1.3 with the following modifications:

- a) it shall not be applied demolding agent in the protection sheets neither in the piping accessories;
- b) center rings shall only use at the extremes;
- c) curves with nominal piping diameters over 6" shall have a centering ring in the middle of the curve;
- d) valves and other accessories shall have specific support for the protection liner.

7.2.2 In the region of backing of supports shall be foreseen the support from treated wood or synthetic materials, such as polyurethane or polyisocyanurate of density equal to or greater than 150 kg/m<sup>3</sup> and engineering plastics, which also provided high-density (see Figures A.22.1, A.22.2 and A.22.3).

**NOTE** When the supports are subjected to shearing tensions treated wood support shall be used mandatorily.

## **7.3 Cylindrical Vertical Tank - with Removal of the Forms**

7.3.1 Use the Figure A.24 as a typical installation drawing of the insulation.

7.3.2 The parties shall be insulated according to the following sequence:

- a) glue spacers of polyurethane or polyisocyanurate according to 7.3.3;
- b) apply on the surface of a side panel a contraction joint according to 6.3.6;
- c) apply on the inner face of the metal mold the demolding agent;
- d) assemble metal mold, constructed by flat sheets of carbon steel, properly cut and mangled, with a height of approximately 1 m, supported over the spacers and fixed with zing steel screws;
- e) apply, by the injection process, the polyurethane foam until the complete filling of the mold;
- f) cut off at an angle of 45° the excess spilled material on the upper face of the mold;
- g) repeat a), c), d), e) and f);
- h) remove the molds after complete cure of the material and visually inspect the injected insulating;
- i) coat the external surface of the two injected rings with a vapour barrier constituted of elastomeric adhesive aluminized asphalt blanket according to 4.24;
- j) repeat the above procedure except b) until the complete insulation of the shell.

7.3.3 The total thickness of the insulation shall be guided at the field by the application of rectangular profile spacers (100 mm base) and length of 1 000 mm.

7.3.3.1 The spacers shall be manufactured from molding in open box, in polyurethane or polyisocyanurate of same density and thermal conductivity of the insulation and cut down to established sizes.

7.3.3.2 The spacers shall be attached to the side panel distanced 1 m between each other.

7.3.4 The top edge of the ceiling constituted by a compression sheet, shall have, in their entire circumference, a flat bar of stainless steel AISI 304 of 50,8 mm x 3,2 mm, welded, which serves to fix the ruff protector of the insulating, see detail A of Figure A.23.1.

7.3.5 The tank accessories such as manholes, piping connections and structural supports shall be insulated, by adopting the injection system in a closed box or pre-molded one.

7.3.6 Assemble the weather and mechanical damage protection on the vapour barrier according to 6.3.14 to 6.3.20.

7.3.7 The quality control of the applied polyurethane shall be based on 8.3.

7.3.8 The fixation systems of insulation (for adherence), of metallic protection (rivets and straps), of vapour barrier (for adherence), may not result in the welding of supports or anchors to the side of the tank, here regarded as cold spot that protrude out of the insulation thickness.

## **8 Qualification and Inspection**

### **8.1 Pre-Molded Insulating**

8.1.1 Where vapour barrier, consisting of two layers of impermeable asphalt or elastomeric base, interspersed with fiberglass tissue, is applied, it shall be measured the thickness of the vapour barrier after drying, adopting the following sequence:

- a) remove a test specimen with a section of 20 mm x 20 mm, without causing excessive damages to the insulating material;
- b) measure the thickness of the vapour barrier at the test specimen;
- c) repair insulation and the vapour barrier immediately after the removal of the test specimen.

8.1.2 To the measurements number determination, meet the following criteria:

- a) equipment with an area less than 200 m<sup>2</sup>: two measurements;
- b) equipment with an area exceeding 200 m<sup>2</sup>: add one more measurement for each 200 m<sup>2</sup> or additional area fraction;
- c) piping: one measurement to each 200 m in length.

8.1.3 Check if occurred looseness due to contraction in the regions of interference pieces after the pre-operation of the piping or equipment.

8.1.4 Immediately prior to application of protection against the weather and mechanical damages, conduct a complete visual inspection throughout the vapour barrier, in order to determine possible damage or discontinuities.

### **8.2 Insulating of Designed Polyurethane (Pulverization)**

8.2.1 The application procedure shall be qualified as follows:

- a) to project the material on a steel panel, measuring 1,2 m x 1,2 m (positioned vertically), with surface preparation and painting identical to the equipment or piping, so that has a thickness of 100 mm after the end of application;
- b) measure the thickness of the insulating in at least six points of the panel;
- c) remove test specimens with dimensions of 230 mm x 115 mm x 100 mm, verifying the insulating adherence to the substrate, aiming at the preparation of test specimens;

- d) visually inspect the test specimens, verifying if there are gaps and if the chemical reaction of foam formation developed perfectly (cells with size and homogeneous distribution);
- e) perform the tests as indicated in the specification of the respective material in PETROBRAS [N-1618](#), using at least three test specimens for each test:
  - apparent specific mass;
  - mechanical resistance (compression);
  - amount of closed cells;
  - maximum linear variation;
  - water absorption.

8.2.2 After the qualification of the application procedure, all gun operators shall be qualified as described in 8.2.1.

8.2.3 It shall be done, daily, the projection of the insulation in panel of 300 mm x 300 mm, previously prepared with demolding agent, in the thickness of insulation, for the test specimen withdrawal of 100 mm x 100 mm, performing:

- a) visually inspect, verifying if there are gaps and if the chemical reaction of foam formation developed perfectly (cells with size and homogeneous distribution);
- b) determine the apparent specific mass.

8.2.4 The application of the insulating material shall only be initiated after the approval of the tests described in 8.2.3.

8.2.5 When the vapour barrier is composed of two layers of impermeable asphalt base or elastomeric, interspersed with fiberglass tissue, the thickness of the vapour barrier should be checked every 10 m<sup>2</sup> of insulated area by material consumption and inspected according to 8.1.1, 8.1.2 and 8.1.3.

### **8.3 Insulating of Injected Polyurethane**

8.3.1 The application procedure shall be qualified as follows:

- a) prepare two tests specimens established of 50 mm (2") diameter pipes and 1 000 mm long with removable cover sheet (see Note) considering 110 mm of thickness insulation and applied demolding agent on the inner surface of protection sheet;
- b) injecting the material according to the procedure to be qualified, with a pipe on a vertical position and other on an horizontal one;
- c) verify if the insulation spilled through the vent holes and does not on the overlap of the sheet;
- d) allow material to cure;
- e) remove the protection sheets;
- f) verify that the insulating filling all the empty spaces and if does not present superficial cavities;
- g) take out, from each vertical or horizontal part, blocks with dimensions of 230 mm x 115 mm x 110 mm, for making the tests specimen;
- h) verify the adherence of the blocks on the pipe;
- i) visually inspect the blocks, verifying if they present gaps and if the chemical reaction of foam formation developed perfectly (cells with size and homogeneous distribution);
- j) perform the following tests as indicated in the specification of the respective material in PETROBRAS [N-1618](#):
  - apparent specific mass;
  - compression resistance;
  - amount of closed cells;
  - maximum linear variation;
  - water absorption.

NOTE We recommend using protective sheet according to Table 6. **[Recommended Practice]**

8.3.2 After the qualification of the application procedure, all applicators shall be qualified as described in 8.3.1.

8.3.3 Daily, at the beginning and end of the workday, shall be done an injection in a box with dimensions of 100 mm x 100 mm x 100 mm, performing:

- a) opening the box after material reaction;
- b) visually inspect, verifying if they presented gaps and the chemical reaction of foam formation developed perfectly (cells with size and homogeneous distribution);
- c) determine the apparent specific mass.

8.3.4 The application of the insulating material shall only be initiated after the approval of the tests described in 8.3.3.

8.3.5 Perform the percussion test with a rubber hammer of 250 g, on the cover sheet, at least 20 % of the insulated area, in order to detect possible gaps in the insulation material applied, determined by the various sound effects generated.

8.3.6 For piping, remove the cover sheet at 100 m, 200 m, 500 m and at each 500 m subsequent, and:

- a) remove five blocks of the insulating with dimensions of 230 mm x 115 mm x thickness of insulation, for making test specimen;
- b) check the adhesion of the insulating material to substrate;
- c) visually inspect the blocks, verifying if they presented gaps and the chemical reaction of foam formation developed perfectly (cells with size and homogeneous distribution);
- d) determine the apparent specific mass.

8.3.7 For equipment, perform an inspection in accordance with 8.3.6 for each injection ring.

## **8.4 Operation Inspection**

For inspection of the piping insulation and equipment can be used thermography process, so as not to need to remove the insulation or part of it, preserving the physical integrity of the installation. **[Recommended Practice]**

## **9 Acceptance and Rejection**

### **9.1 Pre-molded Insulating**

9.1.1 Where a vapour barrier is composed of two layers of impermeable asphalt base or elastomeric, interspersed with fiberglass tissue, the thickness of the vapour barrier, when measured according to 8.1.1, shall have a value comprehended between 100 % and 130 % of the defined thickness in the design.

9.1.1.1 If the performed measure does not meet the defined criteria in 9.1.1, the measurement shall be repeated as follows:



- a) in the case of equipment, perform four new measures at points diametrically opposed and spaced 300 mm away from each other;
- b) in the case of piping, perform four new measures, one shall be done in an upper region, one in the bottom region of the pipe and two along the pipe axis, in opposite directions and spaced 300 mm away compared to original measure.

9.1.1.2 If the measures found in 9.1.1.1 meet the criteria set, the vapour barrier inspected shall be accepted, otherwise, the affected region shall undergo a new application of waterproofing and the number of measurements determined in 8.1.2 shall be extended to:

- a) equipment with an area less than 200 m<sup>2</sup>: four measurements;
- b) equipment with an area exceeding 200 m<sup>2</sup>: add two more measurements to each 200 m<sup>2</sup> or additional area fraction;
- c) piping: two measurement to each 200 m in length.

NOTE 1 If the vapour barrier is present at low thickness on the entire coated surface it shall be redone in its entirety.

NOTE 2 If the thickness of the vapor barrier is greater than 130 % of the thickness defined in the design it shall be evaluated the over-consumption of material for execution of the vapour barrier.

9.1.2 If clearances are detected, analyzed according to 8.1.3, the not dryable sealant shall be reapplied.

9.1.3 The vapour barrier performed with elastomeric blanket shall not present clearances and/or discontinuities.

9.1.4 The weather damages protection is accepted when presented properly engaged and sealed.

## **9.2 Insulating of designed polyurethane (Pulverization)**

9.2.1 The enforcement procedure is qualified if:

- a) the thickness measurements, according to b) of 8.2.1, are between 100 mm and 120 mm;
- b) the blocks of insulating, removed according to c) of 8.2.1, present resistant to detachment;
- c) the blocks of insulating, inspected according to d) of 8.2.1, do not present gaps or formation of cells with heterogeneous size and distribution;
- d) the test specimens, tested according to e) of 8.2.1, meet the criteria fixed on PETROBRAS [N-1618](#).

9.2.2 If any of the enumerations of 9.2.1 has not been met, the enforcement procedure shall be requalified.

9.2.3 The application of insulating in the region that is being evaluated shall be accepted if the test specimen, made in accordance with 8.2.3, does not present gaps or formation of cells with heterogeneous size and distribution, and if the apparent specific mass is according to indicated in the specifications of the respective material in PETROBRAS [N-1618](#).

9.2.4 In the cases where a vapour barrier is composed of two layers of impermeable asphalt base or elastomeric, interspersed with fiberglass tissue, the thickness of the vapour barrier shall be evaluated according to 9.1.1 and the measure according to 8.2.5.

9.2.5 A vapour barrier carried out with elastomeric blanket shall not present gaps and/or discontinuities.

9.2.6 The weather damages protection is accepted when it is presented properly engaged and sealed.

### **9.3 Insulating of injected Polyurethane**

9.3.1 The enforcement procedure is qualified if:

- a) the insulating, verified as c) of 8.3.1, has spilled through the vent holes and not through the overlap of the sheet;
- b) the insulating, verified as f) of 8.3.1, does not present gaps or superficial cavities greater than 8 mm;
- c) the blocks of the insulating, removed according to g) and h) of 8.3.1, present resistance to displacement;
- d) the blocks of insulating, inspected according to i) of 8.3.1, do not present gaps or formation of cells with heterogeneous sizes and distribution;
- e) the test specimen, tested according to j) of 8.3.1, meet the criteria fixed on specification of the respective material at PETROBRAS [N-1618](#).

9.3.2 If any of the enumerations of 9.3.1 has not been met, the enforcement procedure shall be requalified.

9.3.3 The test specimens obtained in accordance with 8.3.3 shall:

- a) be free of gaps or formation of cells with heterogeneous size and distribution;
- b) have apparent specific mass as indicated in the specification of the respective material at PETROBRAS [N-1618](#), for injected insulating.

9.3.4 The area tested in accordance with 8.3.5 shall not have gaps in the insulating material.

9.3.5 The application of insulating in the region that is being evaluated as 8.3.6 and 8.3.7 should be accepted when:

- a) the insulated region is approved according to 9.3.4;
- b) the test specimens, taken according to a) of 8.3.6, present resistant to detachment according to b) of 8.3.6;
- c) the test specimens taken according to a) of 8.3.6, do not present gaps or formation of cells with heterogeneous size and distribution, according to c) of 8.3.6;
- d) the apparent specific mass, according to d) of 8.3.6, meet the specification of the respective material in PETROBRAS [N-1618](#) for injected insulation.

9.4 The inspected area according to 8.4 is considered accepted as long as the found temperatures in thermography, at the external surface of the insulation or at the protection sheet, are not less than 5 % of those specified in the design, and provided that at this condition does not occur condensation on the surface.

9.5 For the cases of injected insulation with subsequent removal of form, the vapour barrier is accepted as meet the requirements of 9.2.4 or 9.2.5 and the protection sheet meet the requirements of 9.2.6.

## **10 Procedures to Repair the Insulation**

10.1 The repairs in insulation shall be performed using, preferably, the same type of material and method of insulating application, according to original service.

10.2 The repairs shall be performed in accordance to the qualified procedure. The qualification shall occur before the start of services.

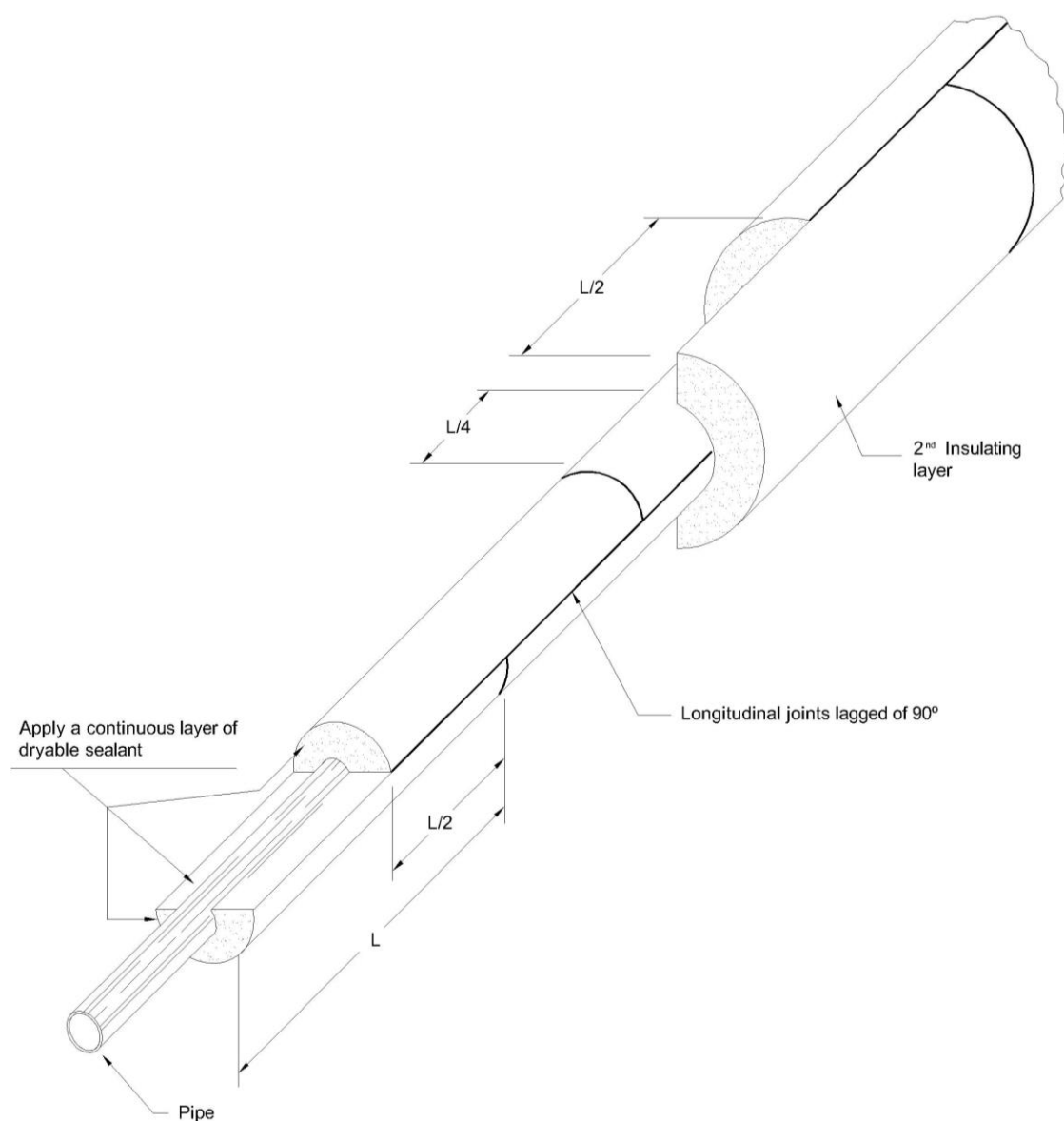
10.3 The insulating material used in the repair shall have an apparent specific mass compatible with the existing insulation material.

10.4 It shall be observed the condition of the surface to be insulated.

10.4.1 The insulation shall be removed, in order not to leave residue of any component of the existing thermal insulation adhered to the surface.

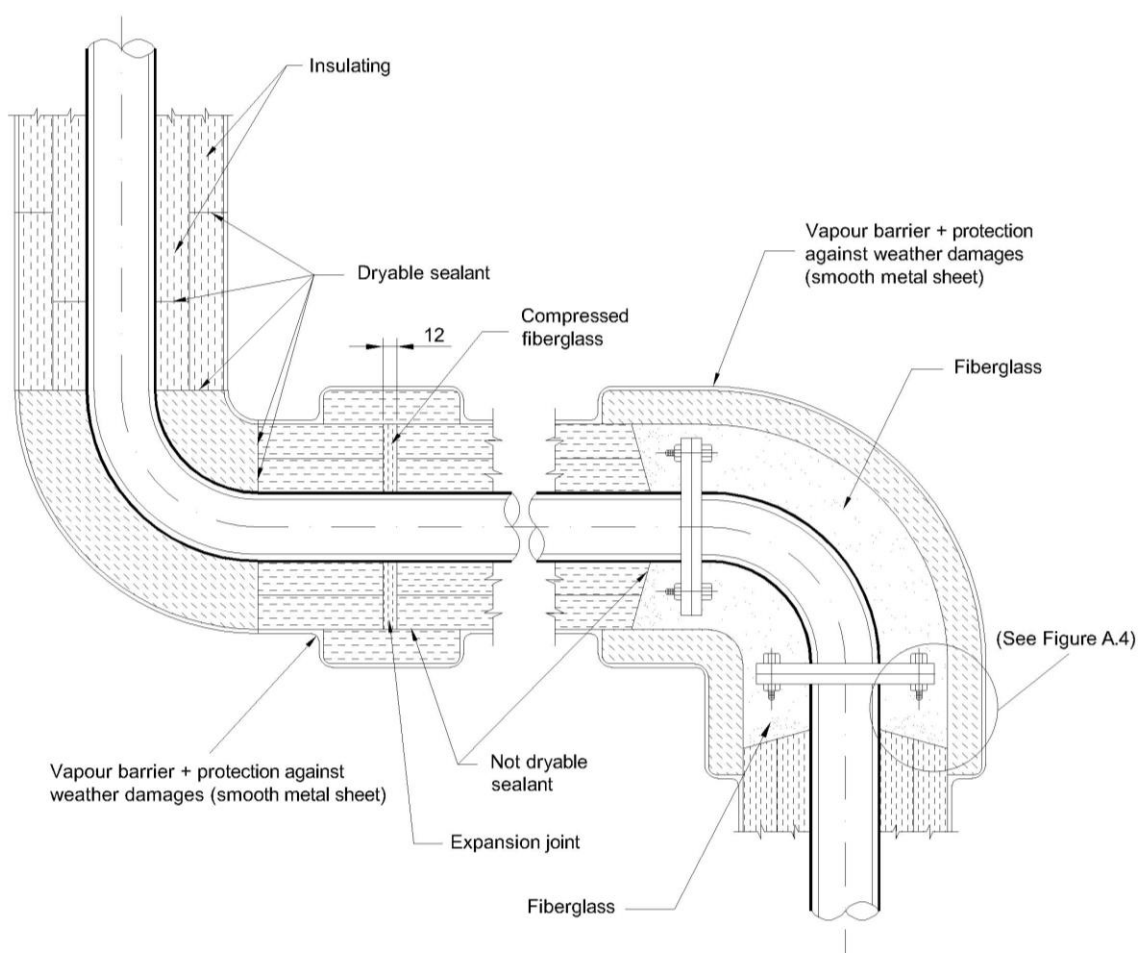
10.4.2 If the surface is painted, it shall be evaluated the necessity of repairs in the paint.

10.5 The repair procedure shall meet the requirements of this Standard.

**Annex A - Figures**


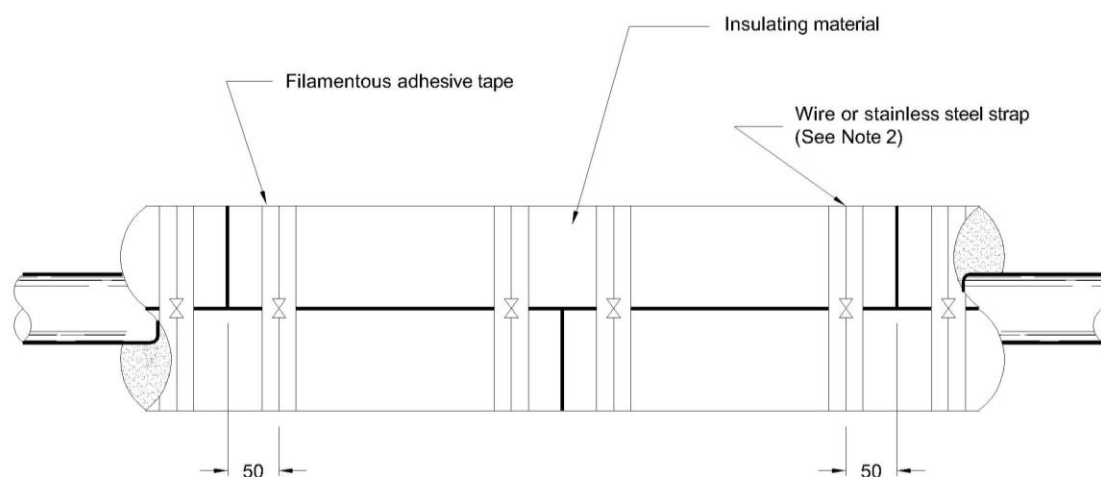
NOTE When the insulating part is a segment, you must lag the segments of a length equal to  $L/N$ , where "L" is the length of the segment and "N" is the number of segments needed for involving the pipe that must be insulated.

**Figure A.1 - Layout of Pre-Molded Insulation Parts**



NOTE Dimensions in millimeters.

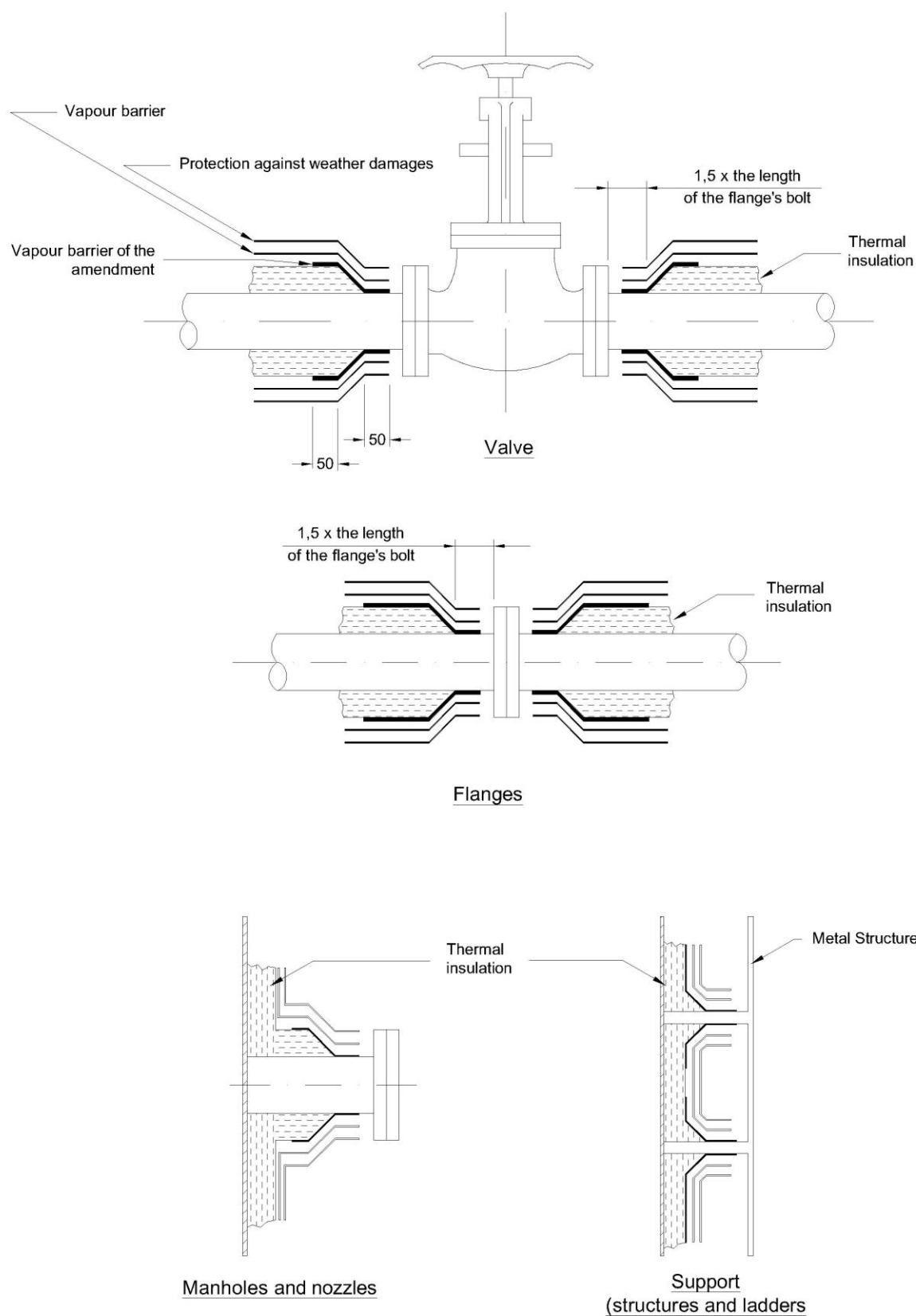
Figure A.2 – Typical Insulation of Flanged Curves and Expansion Joints



NOTE 1 Dimensions in millimeters.

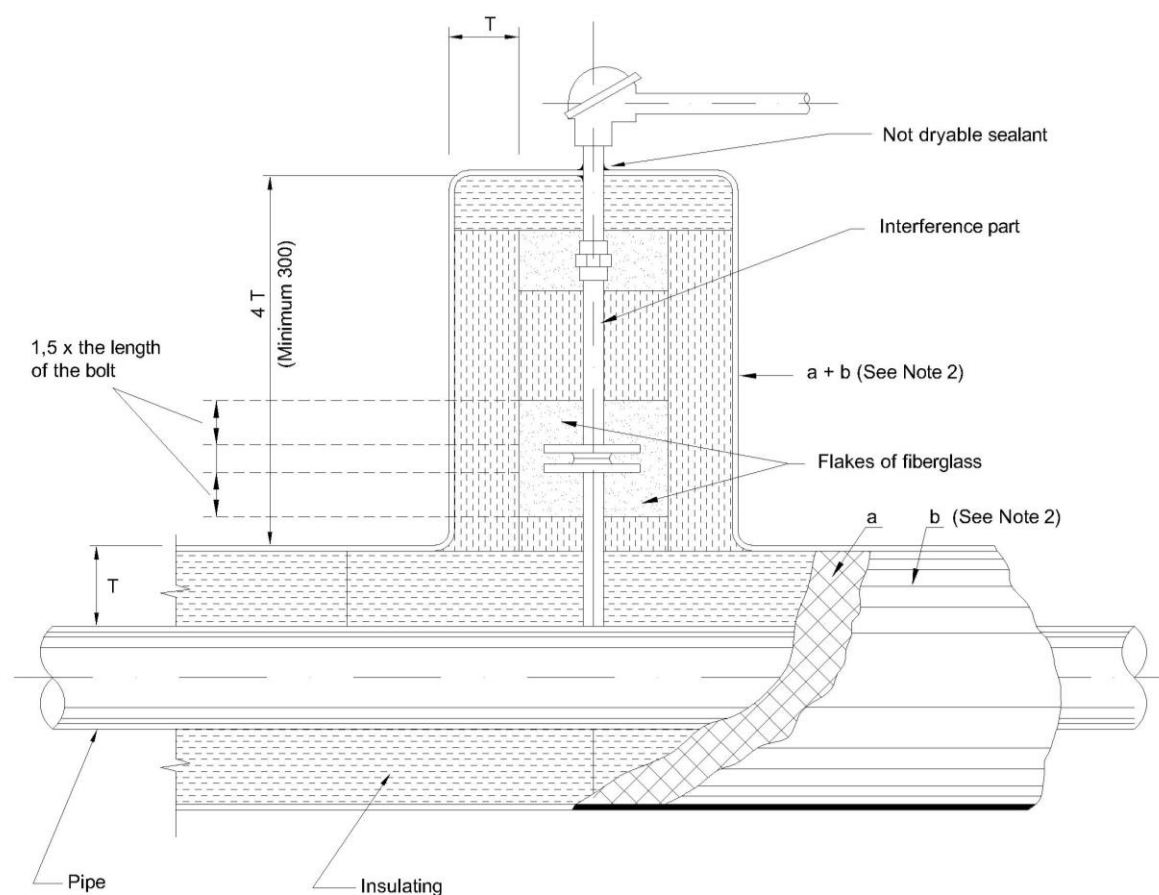
NOTE 2 Use BWG 16 galvanized carbon-steel wire for pipes up to 12" and a 12,7 mm wide stainless steel strap for larger diameters.

**Figure A 3 - Fixture of Insulating Parts in Piping (Single Layer or Last External)**



NOTE Dimensions in millimeters.

**Figure A.4 – Finishing of the Ends of Insulating Layers**



NOTE 1 Dimensions in millimeters.

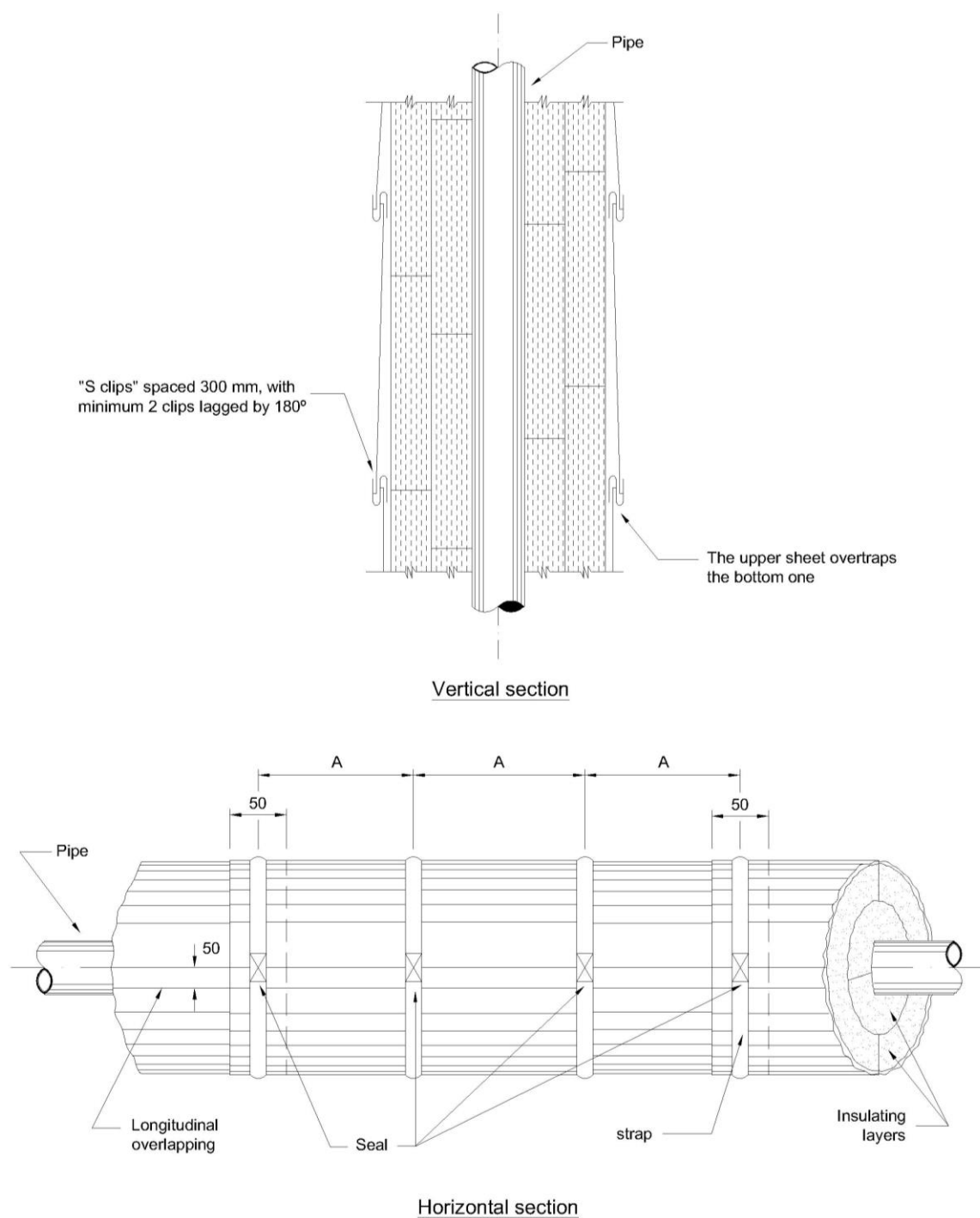
NOTE 2 a = Vapour barrier.

b = Protection against weather damages.

NOTE 3 T = Insulation thickness.

Figure A.5 - Insulation of Interference Part Linked to the Piping





NOTE 1 Dimensions in millimeters.

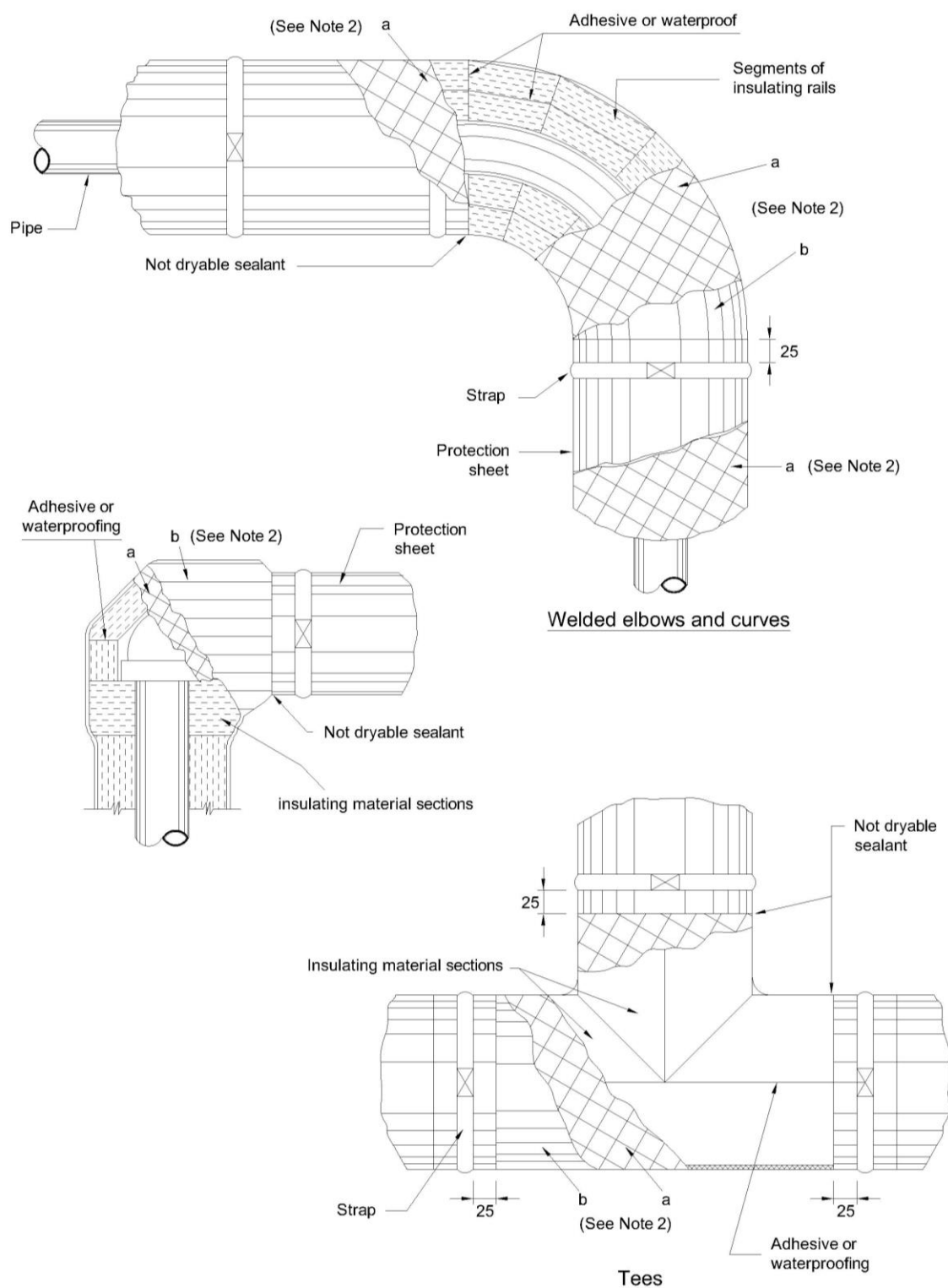
NOTE 2 Use four straps per protection sheet.

NOTE 3 The fixture of the protection sheets in vertical sections follows the same placement of the horizontal one.

NOTE 4 The longitudinal overlapping of the protection sheets shall avoid the penetration of water.

NOTE 5 Value "A" shall appear in the insulation design (typical = 315).

**Figure A.6 – Fixture of the Protection Sheets**

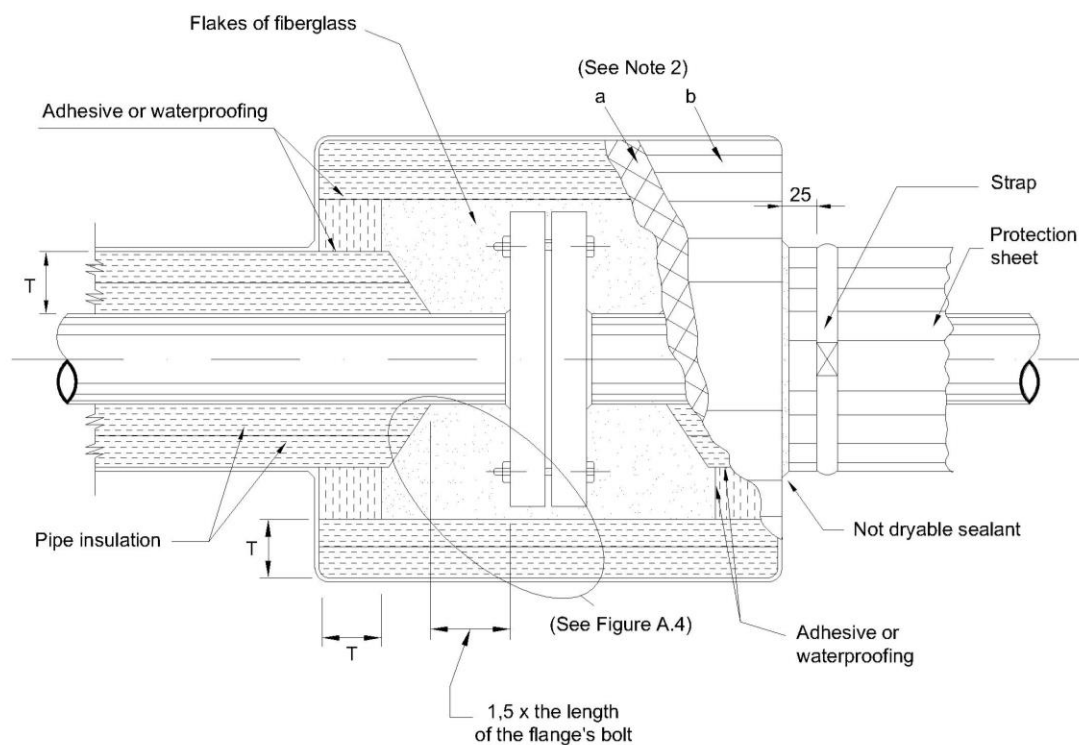


NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier.

b = Protection against weather damages.

Figure A.7 - Typical Insulation of Curves and Connections



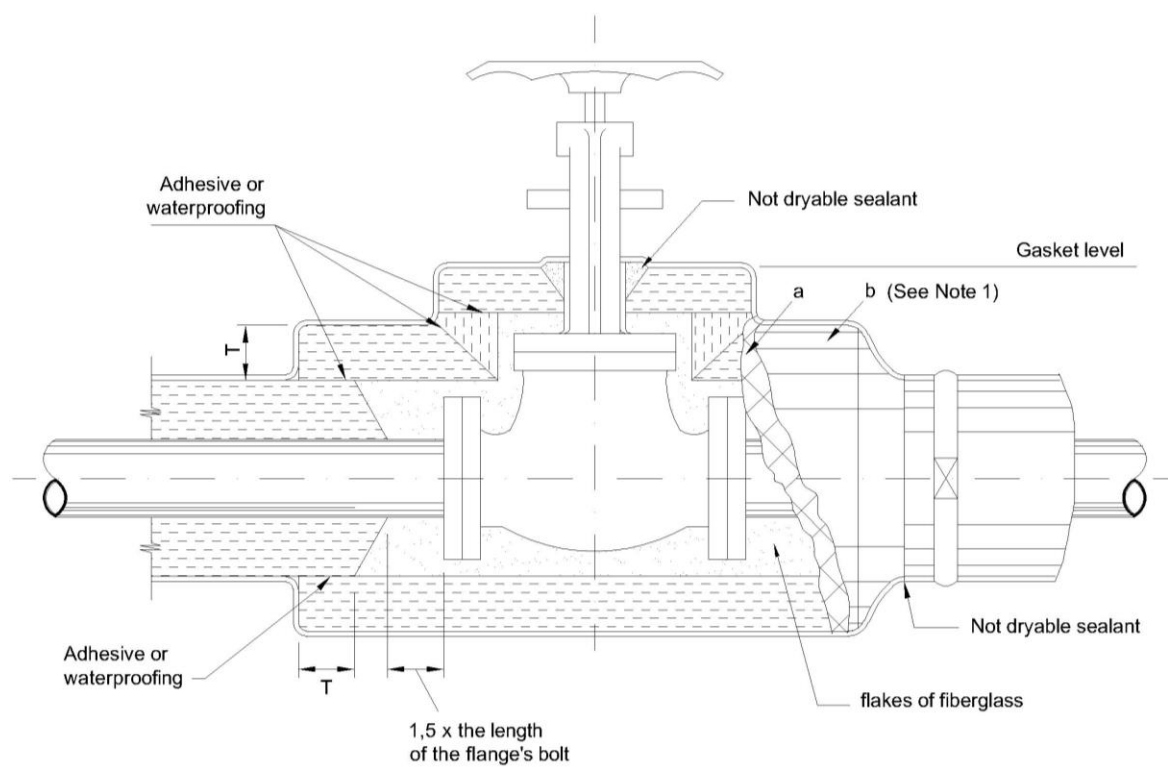
NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier.

b = Protection against weather damages.

NOTE 3 T = Insulation thickness.

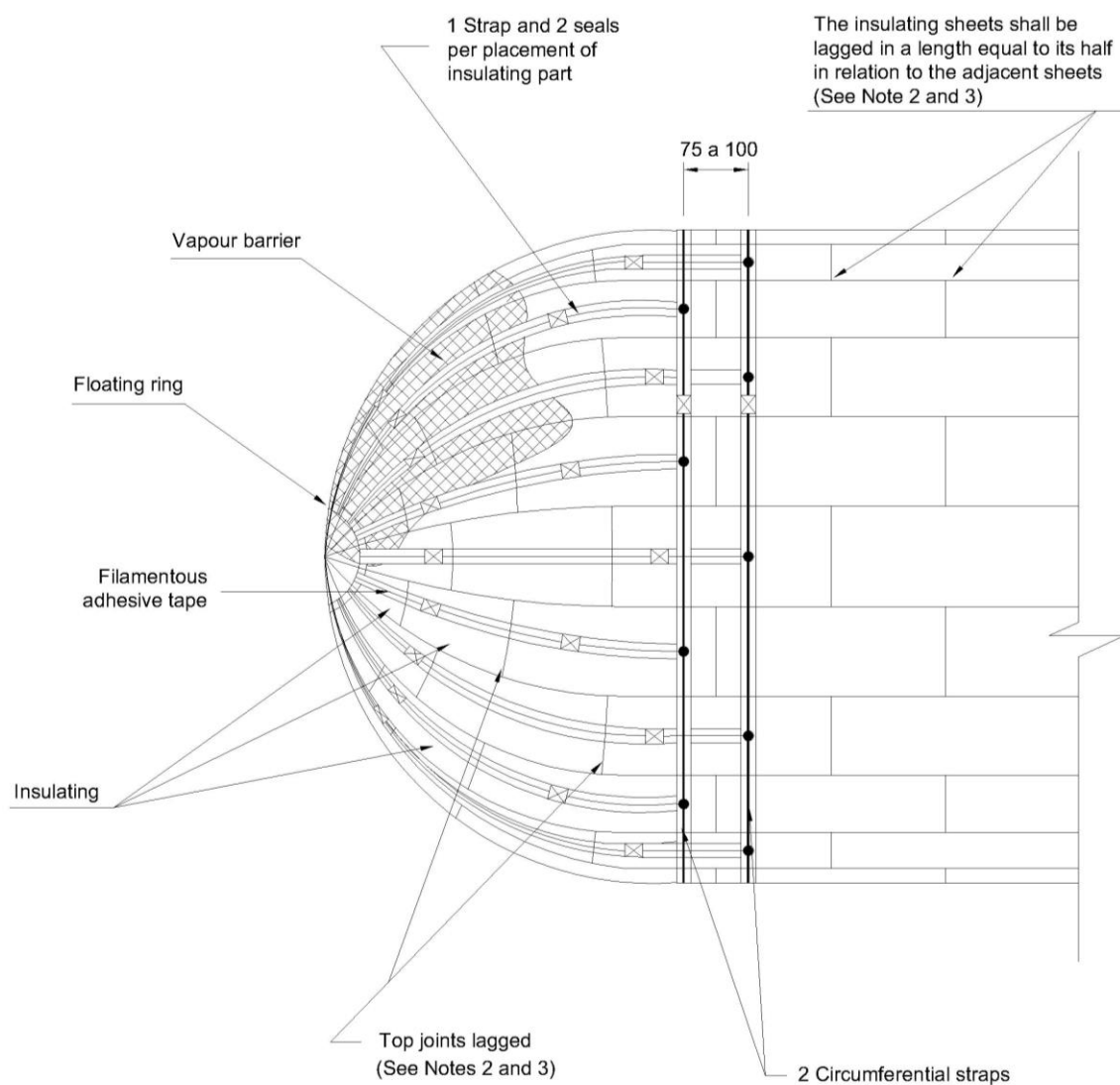
Figure A.8 - Insulation of Flanges



NOTE 1 a = Vapour barrier;  
b = Protection against weather damages.

NOTE 2 T = Insulation thickness.

Figure A.9 - Insulation of Valves

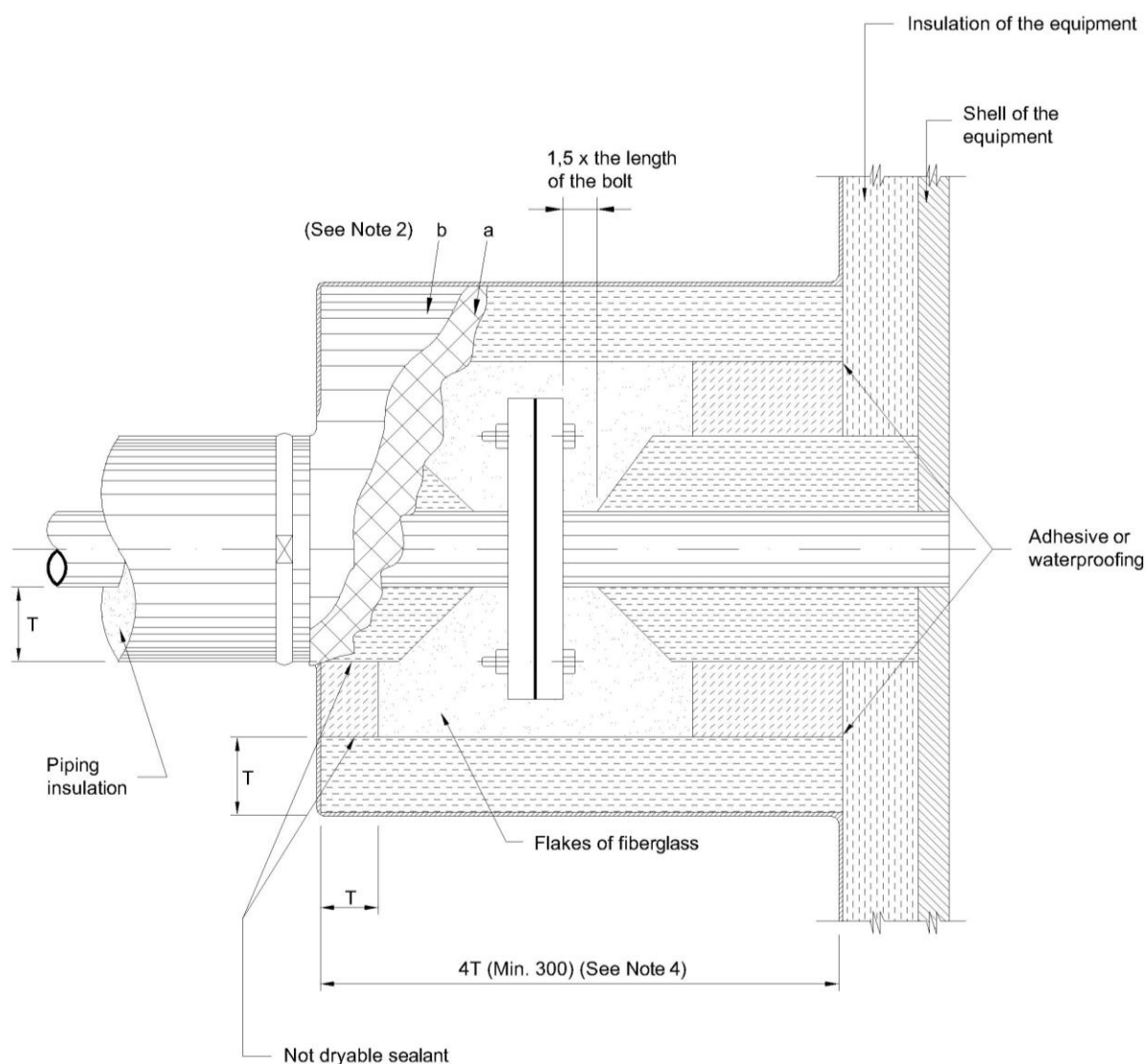


NOTE 1 Dimensions in millimeters.

NOTE 2 The longitudinal and top joints of the 2<sup>nd</sup> layer of the insulating sheets are lagged in relation to the ones of the 1<sup>st</sup>.

NOTE 3 Apply a continuous layer of dryable sealant in all of the joints.

**Figure A.10 - Fixture of the Pre-Molded Insulation in the Union Shell-Lid**



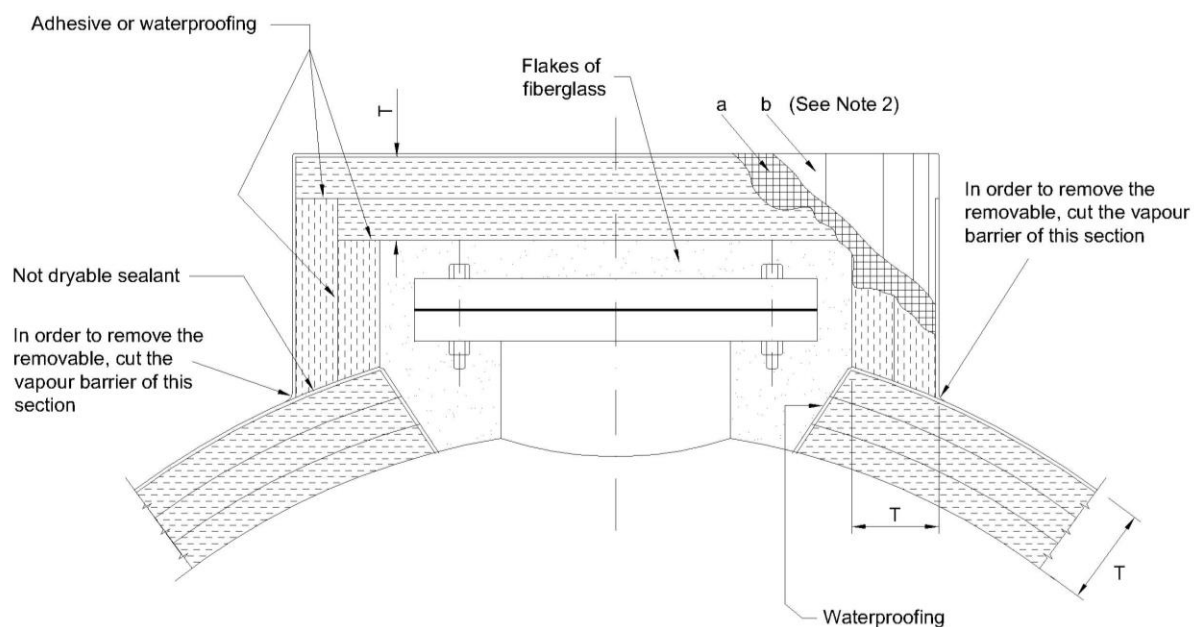
NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier;

b = Protection against weather damages.

NOTE 3 The 4T measure (min. 300) must only be obeyed for the connection of instruments.

**Figure A.11 - Equipment Inlet/Outlet Connection or Instrument Connection**

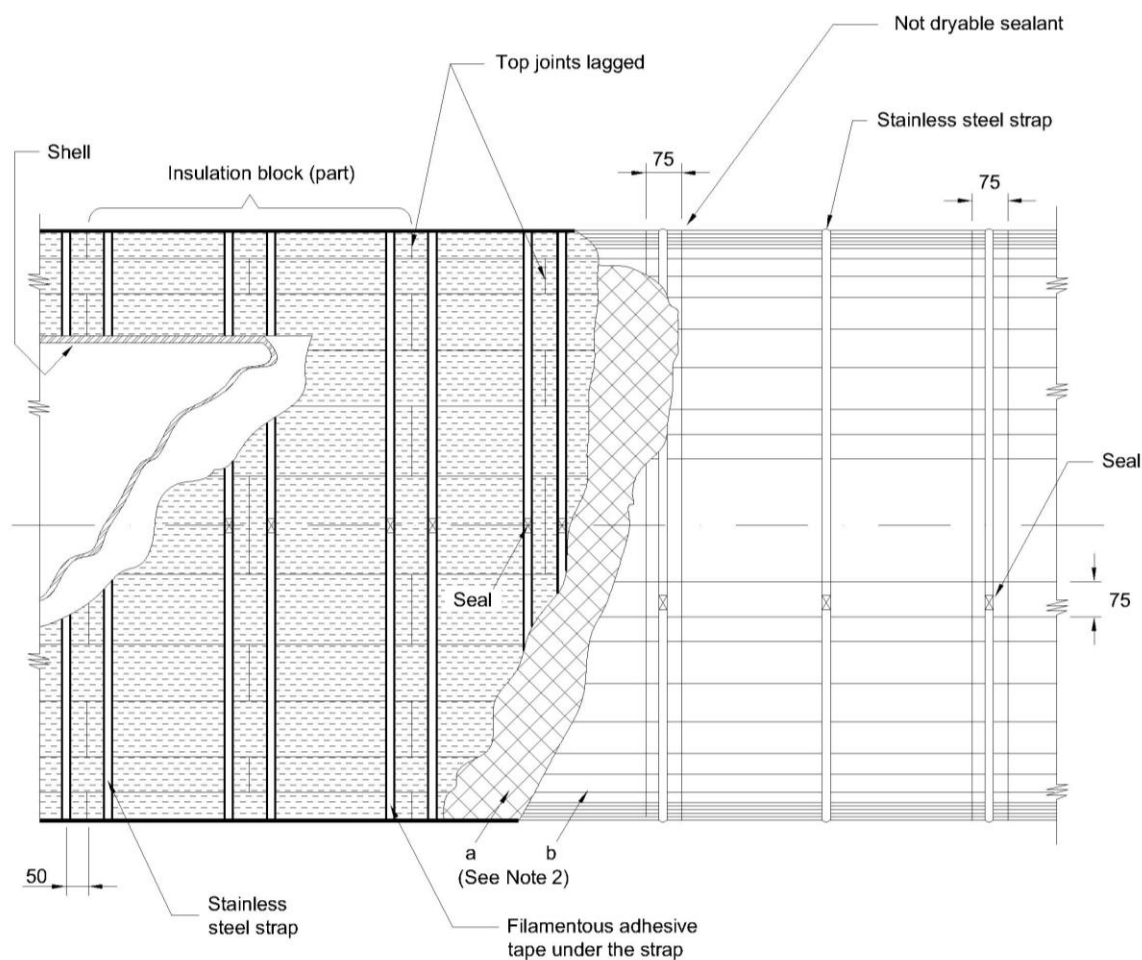


NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier;  
b = Protection against weather damages.

NOTE 3 T = Insulation thickness.

**Figure A.12 - Insulation of Manholes**

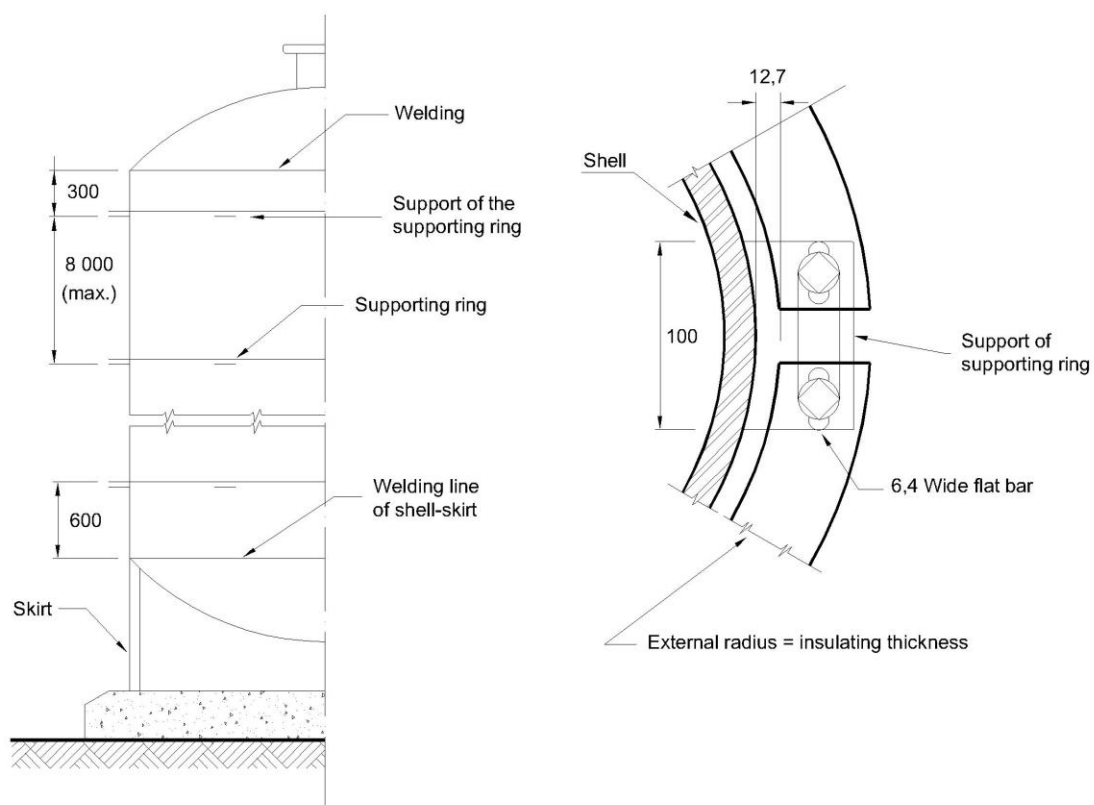


NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier;  
b = Protection against weather damages.

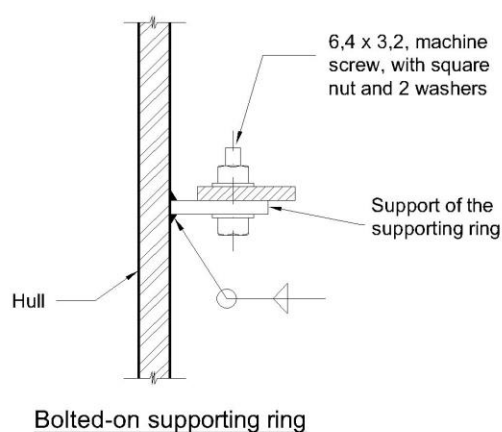
**Figure A.13 - Insulation of Horizontal Vessels' Shell**





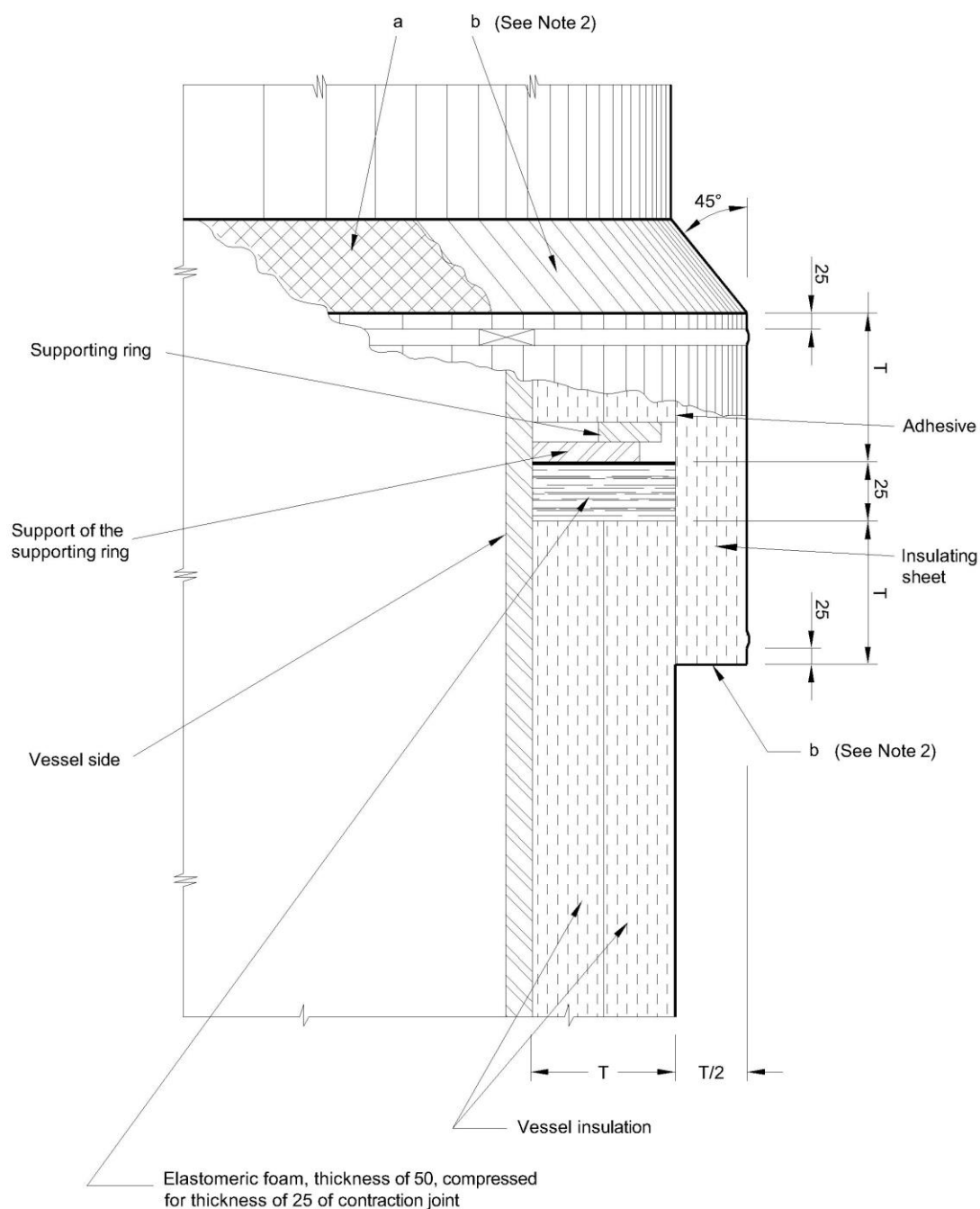
Ring support

Diameter of the vessel	# of supports
Até 1 200	4
1 210 - 2 400	6
2 410 - 3 600	8
3 610 - 4 800	10
4 810 - 6 000	12
> 6 010	Spacing of 1 500



NOTE Dimensions in millimeters.

**Figure A.14 - Support and Support Rings of the Vertical Vessels Insulating**



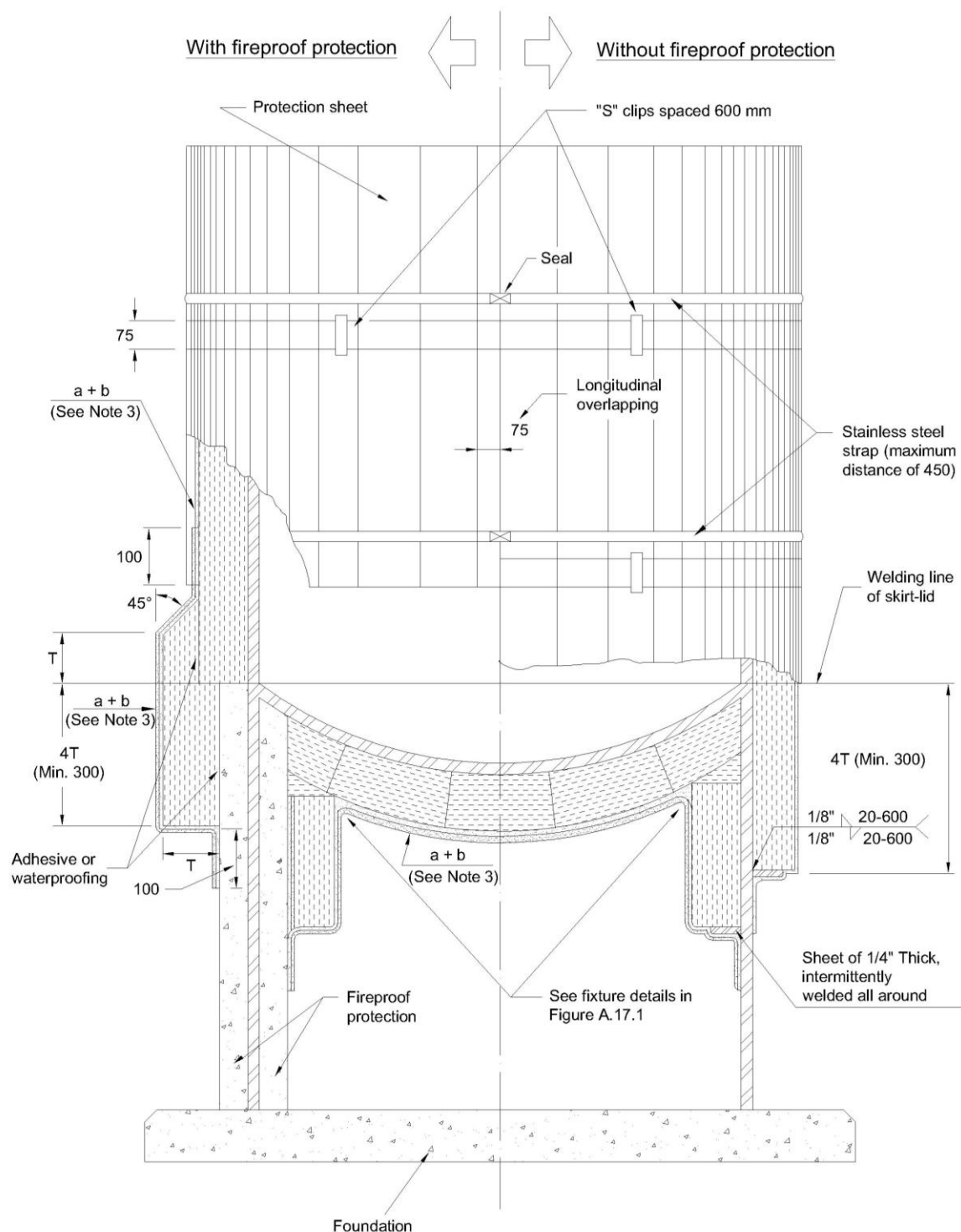
NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier;

b = Protection against weather damages.

NOTE 3 T = Insulation thickness.

**Figure A.15 – Contraction Joint Insulation in Vertical Vessels**



NOTE 1 Dimensions in millimeters, unless otherwise provided.

NOTE 2 a = Vapour barrier.

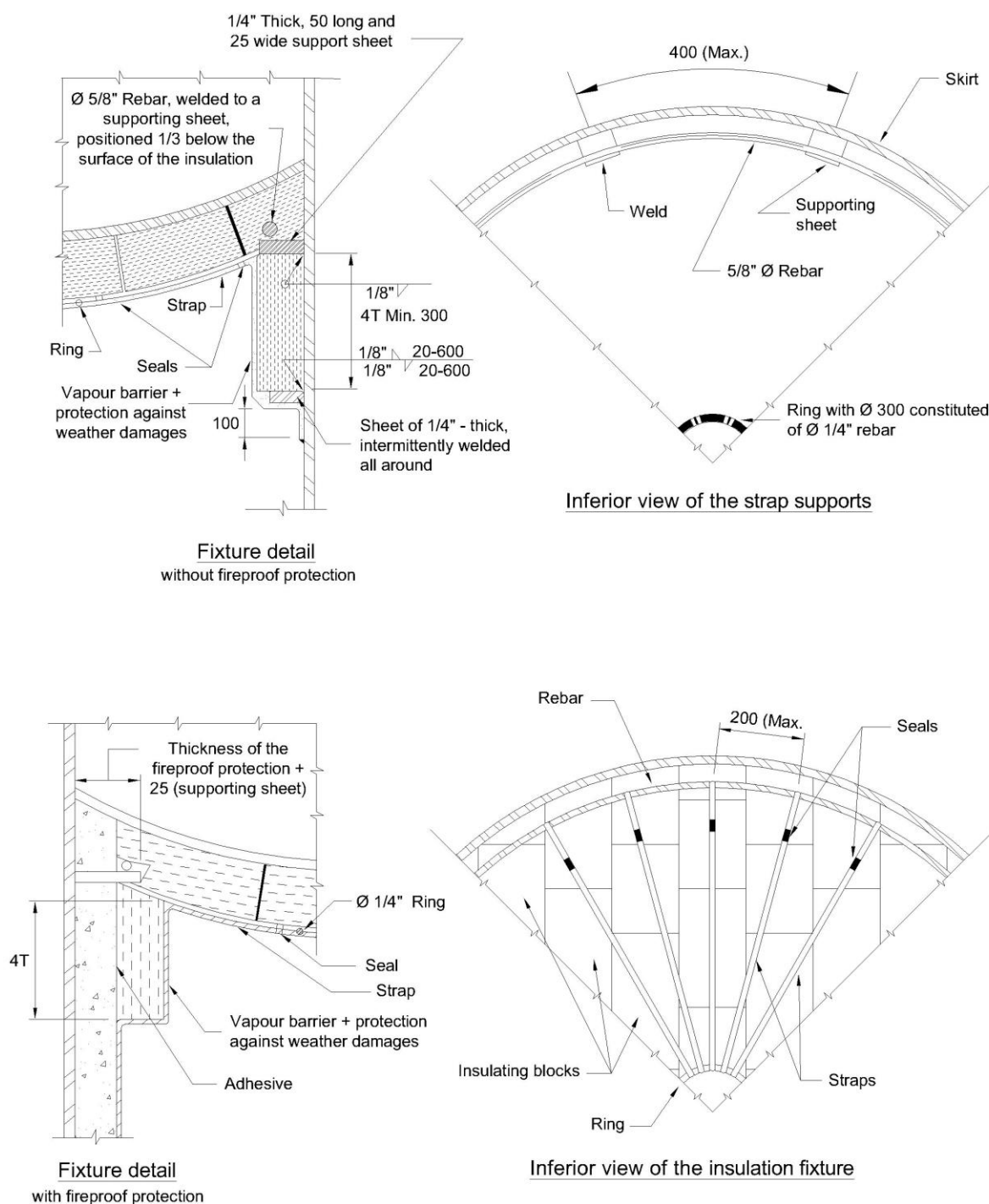
b = Protection against weather damages.

NOTE 3 In inferior round, protected section, interior of the skirt, it is admitted a protection against weather damages made with fiberglass tissue and waterproofing of elastomeric or asphalt-base.

NOTE 4 T = Insulation thickness.

**Figure A.16.1 - General Layout**

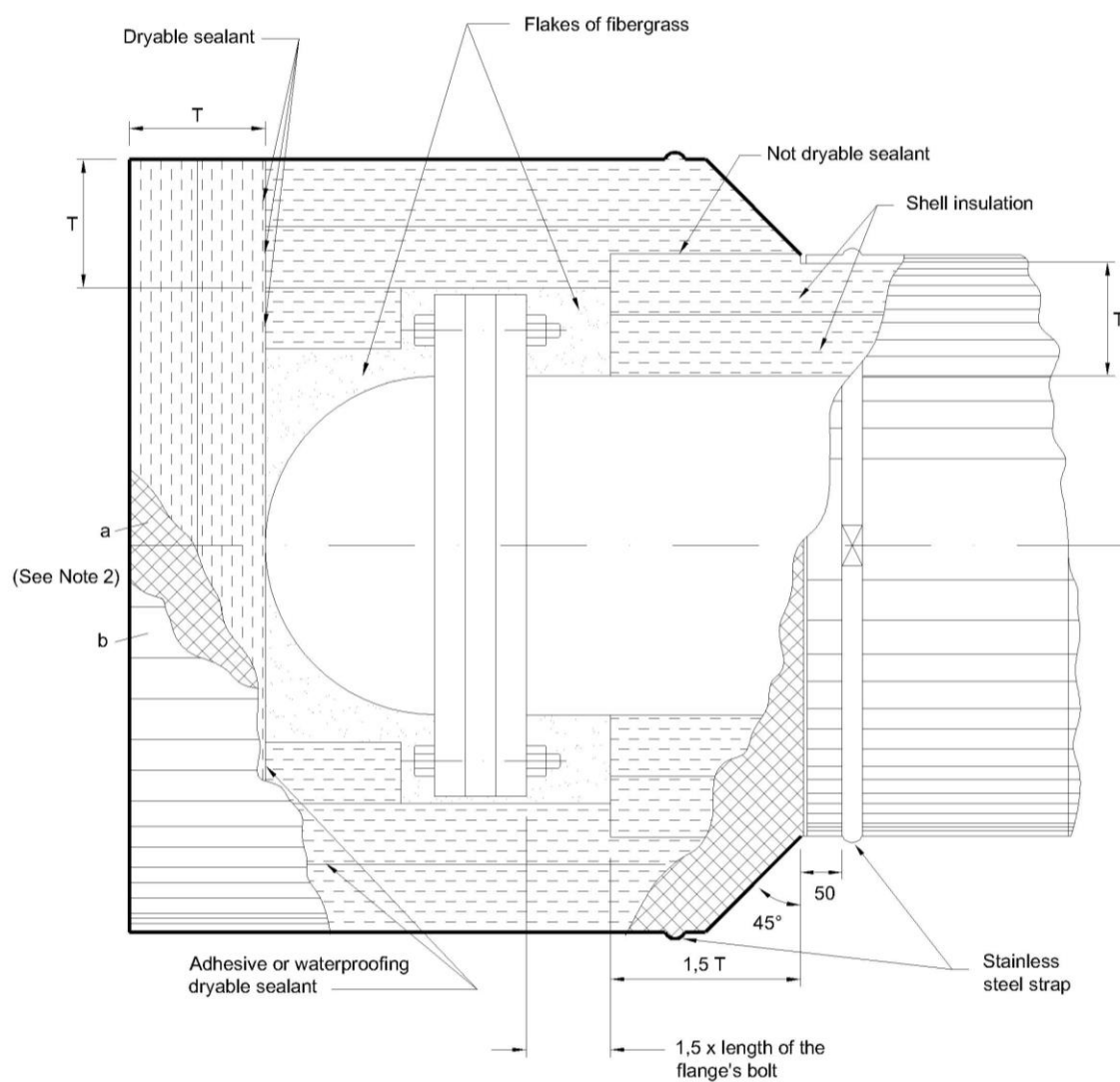
**Figure A.16 - Insulation of Vertical Vessels with and without Fireproof Protection**



NOTE Dimensions in millimeters, unless otherwise provided.

**Figure A.16.2 - Insulation Details**

**Figure A.16 - Insulation of Vertical Vessels with and without Fireproof Protection**



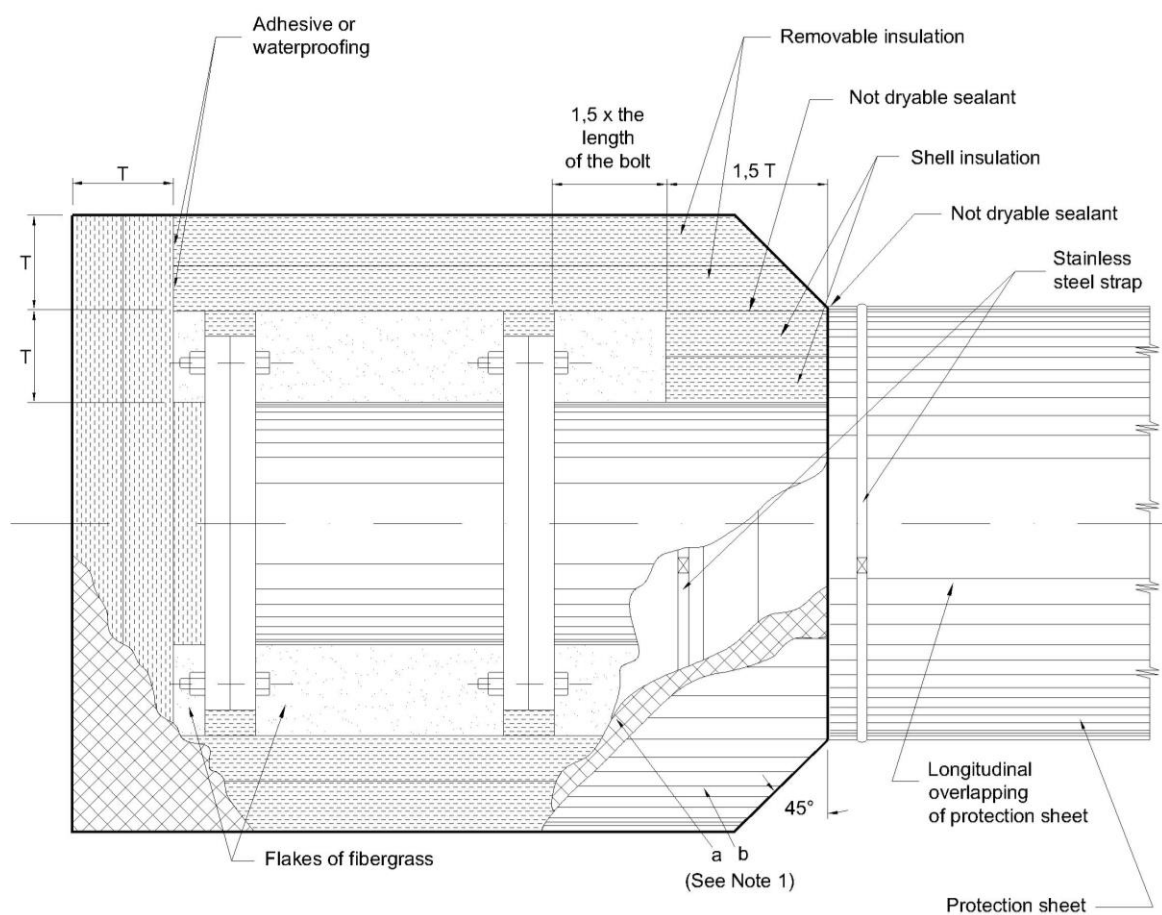
NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier.

b = Protection against weather damages.

NOTE 3 T = Insulation thickness.

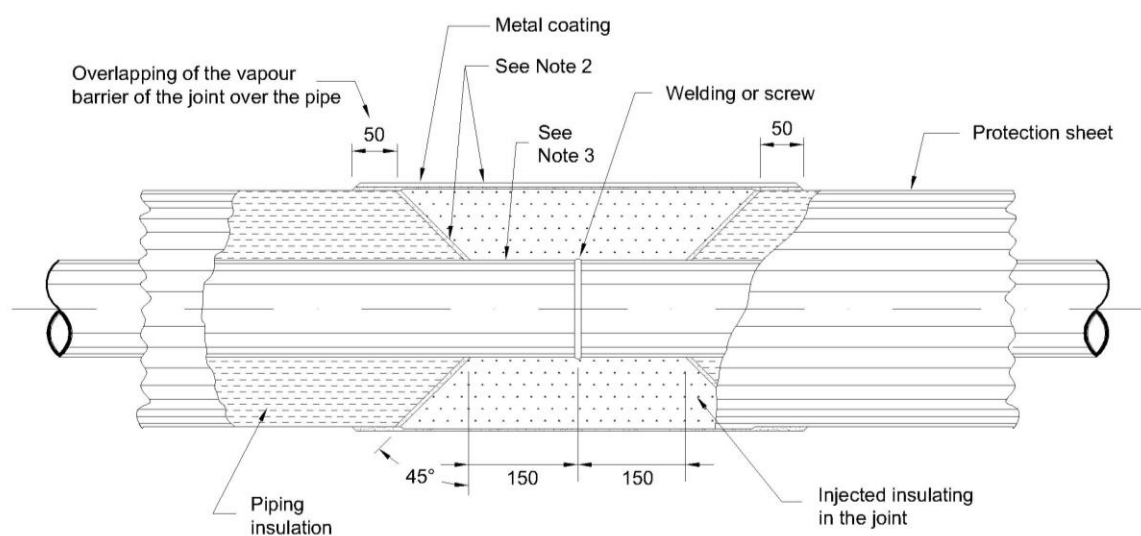
**Figure A.17 - Insulation of Roundish Lid of Heat Exchangers**



NOTE 1 a = Vapour barrier.  
b = Protection against weather damages.

NOTE 2 T = Insulation thickness.

Figure A.18 - Spool Insulation of Heat Exchangers

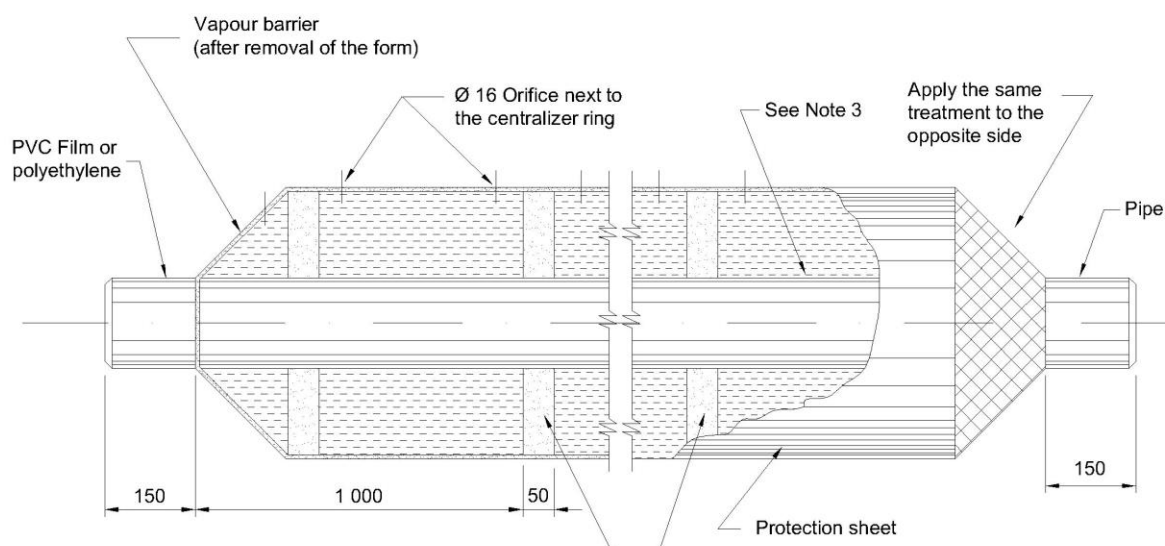


NOTE 1 Dimensions in millimeters.

NOTE 2 a = Vapour barrier.

NOTE 3 PVC film or polyethylene.

**Figure A.19 - Insulation of Piping Amendment**



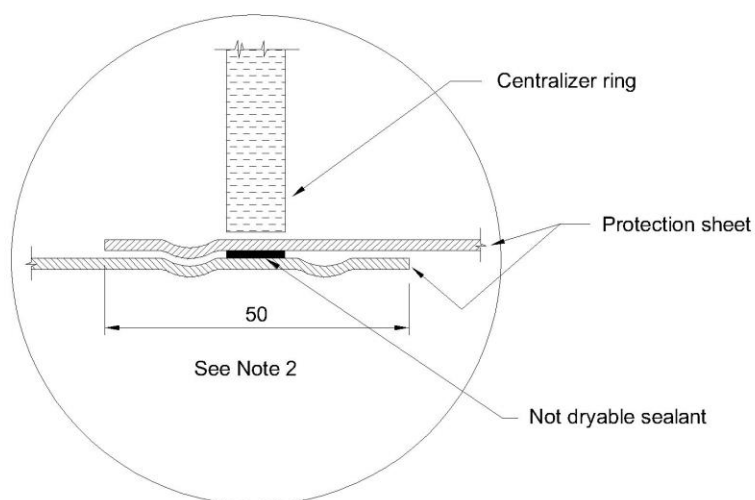
NOTE 1 Dimensions in millimeters.

NOTE 2 The rings can also be fixed to the pipe with adhesives.

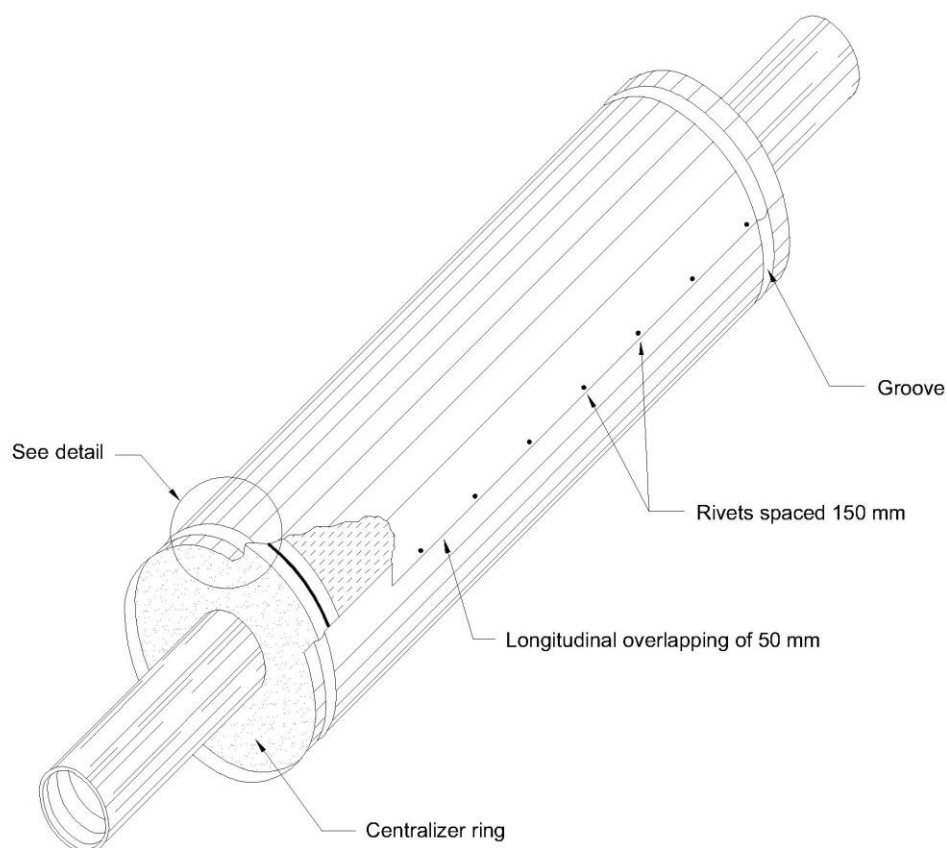
NOTE 3 PVC film or polyethylene.

**Figure A.20 - Insulated Pipe by Injection (Factory)**





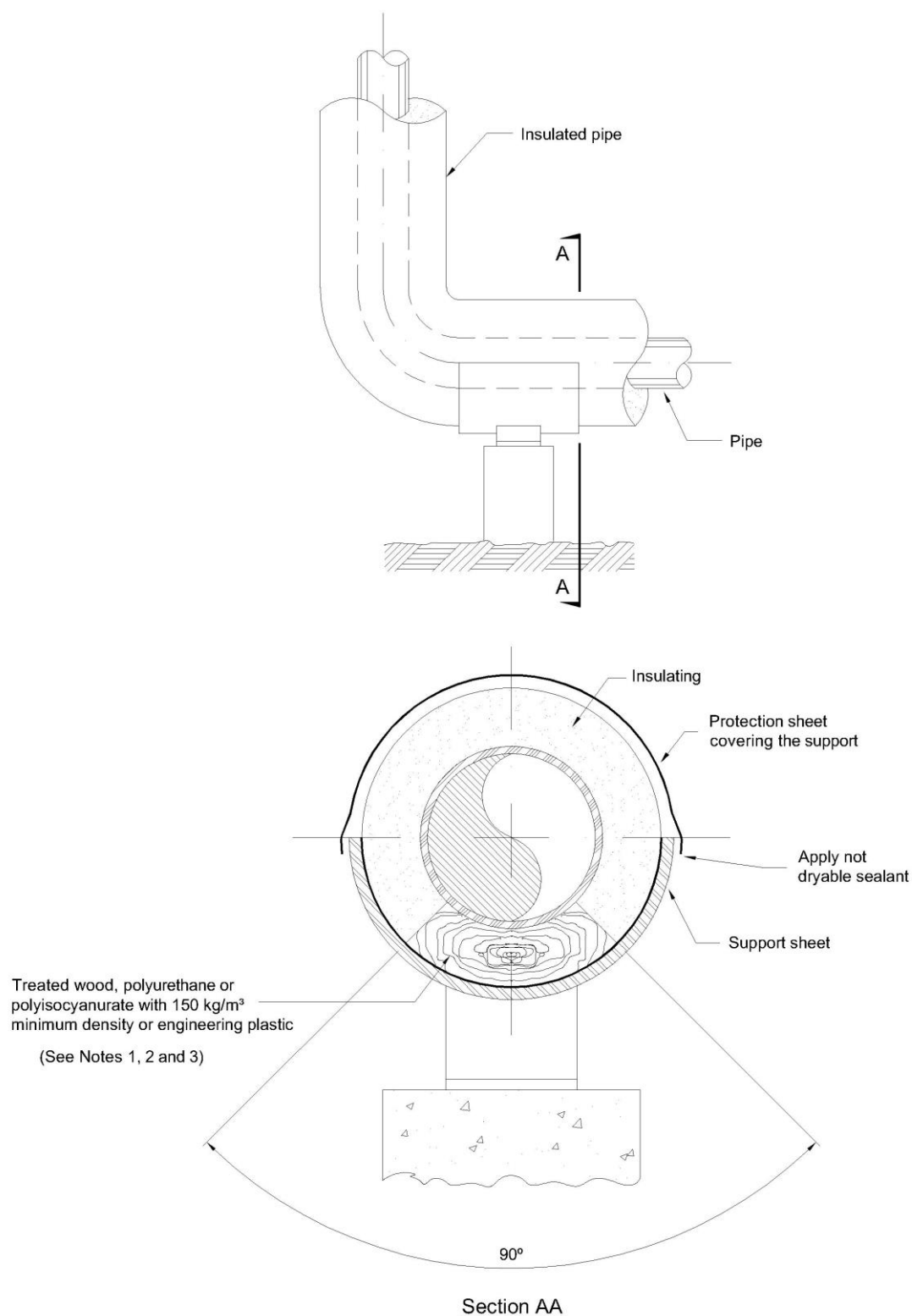
Detail



NOTE 1 Dimensions in millimeters.

NOTE 2 For external diameters above 12", use rivets to fix the circumferential joints.

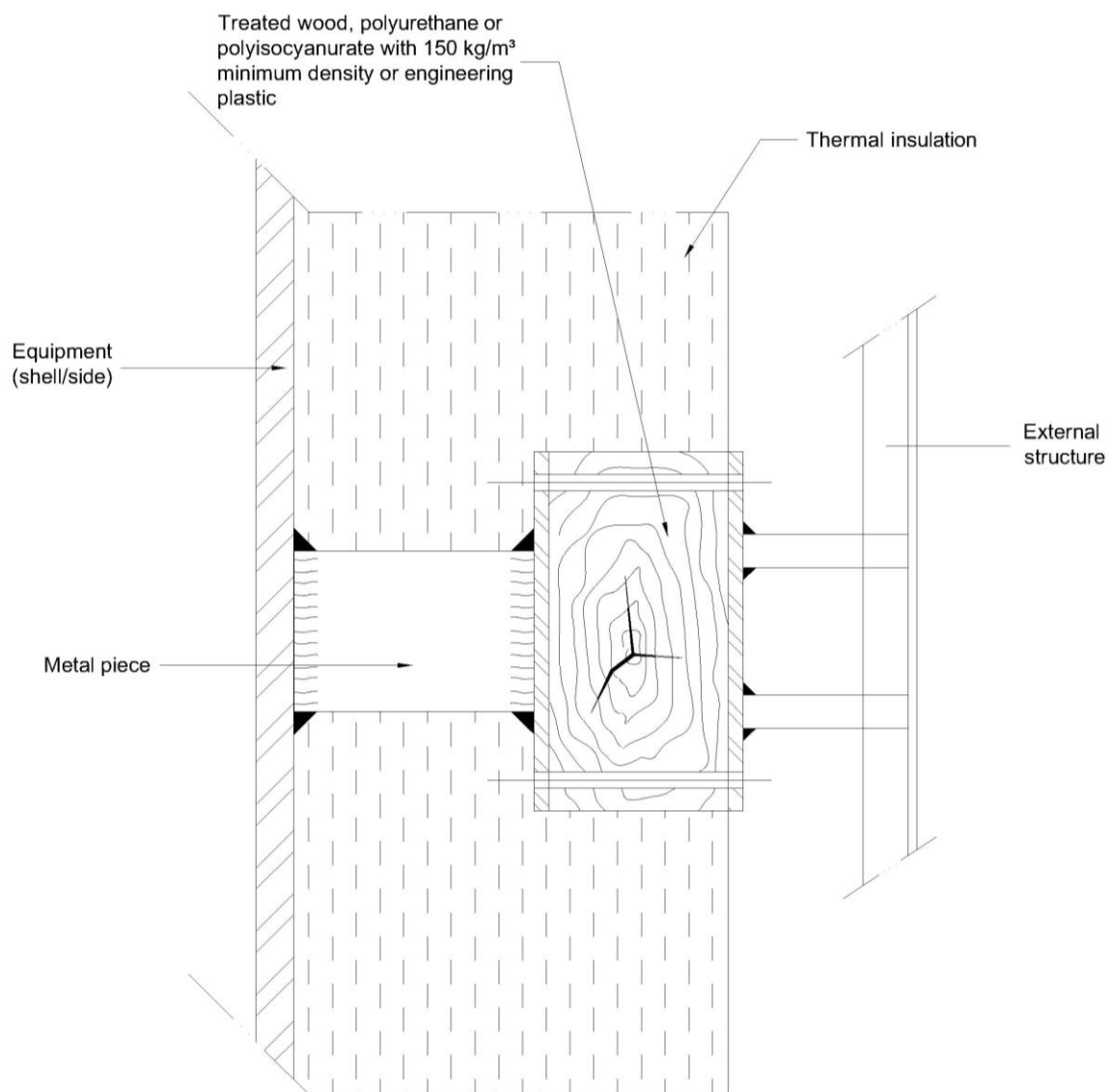
**Figure A.21 - Insulated Pipe by Injection (Field)**

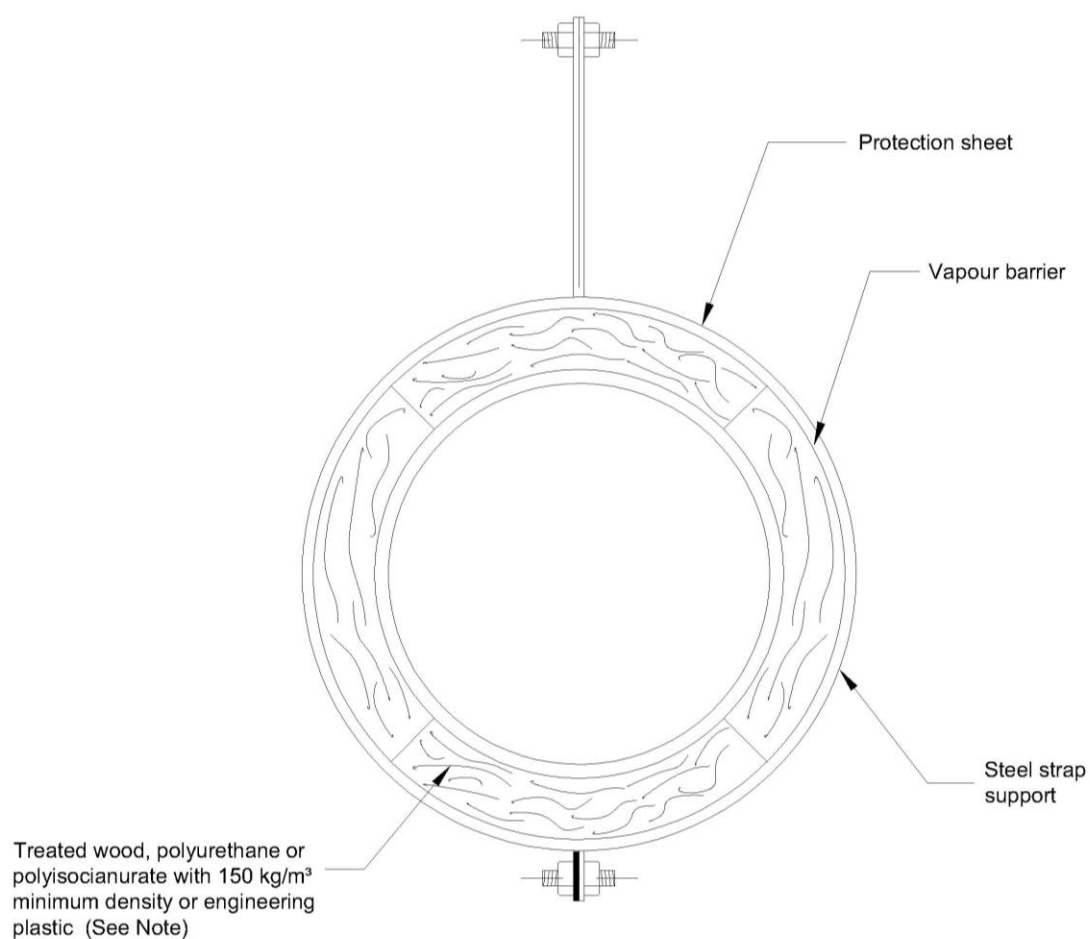


- NOTE 1 Conservative treatment of the wood in an autoclave.  
 NOTE 2 For supports with shearing tensions, the use of wood is mandatory.  
 NOTE 3 Minimum length of the support - 210 mm.

**Figure A 22.1 - Insulated Support for Overhead Pipes**

**Figure A.22 - Insulated Support**

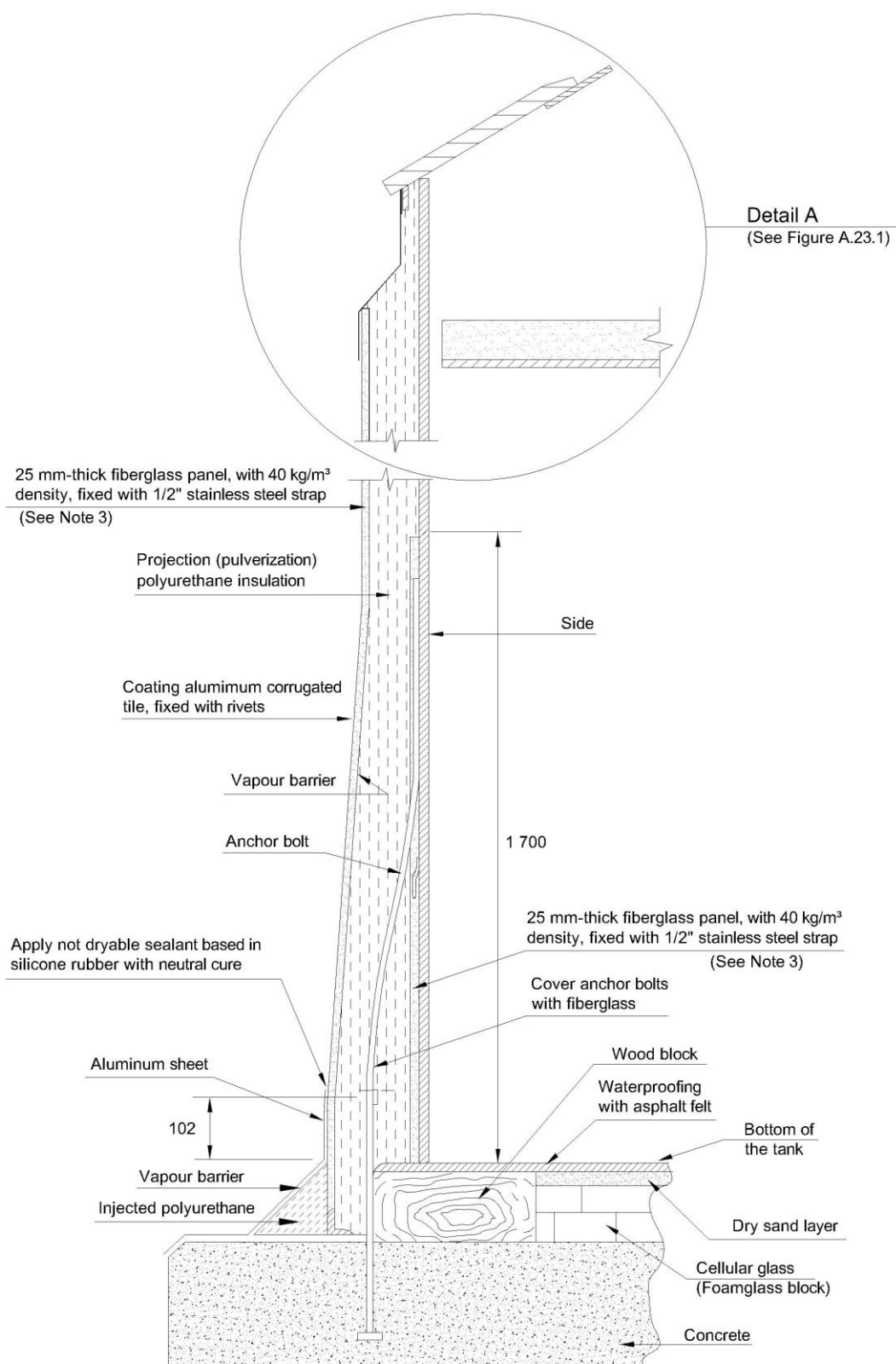

**Figure A.22.2 – Detail of Insulated Support**
**Figure A.22 - Insulated Support**



NOTE Minimum length of the 210 mm support.

**Figure A.22.3 - Insulated Support Airlines**

**Figure A.22 - Insulated Support**



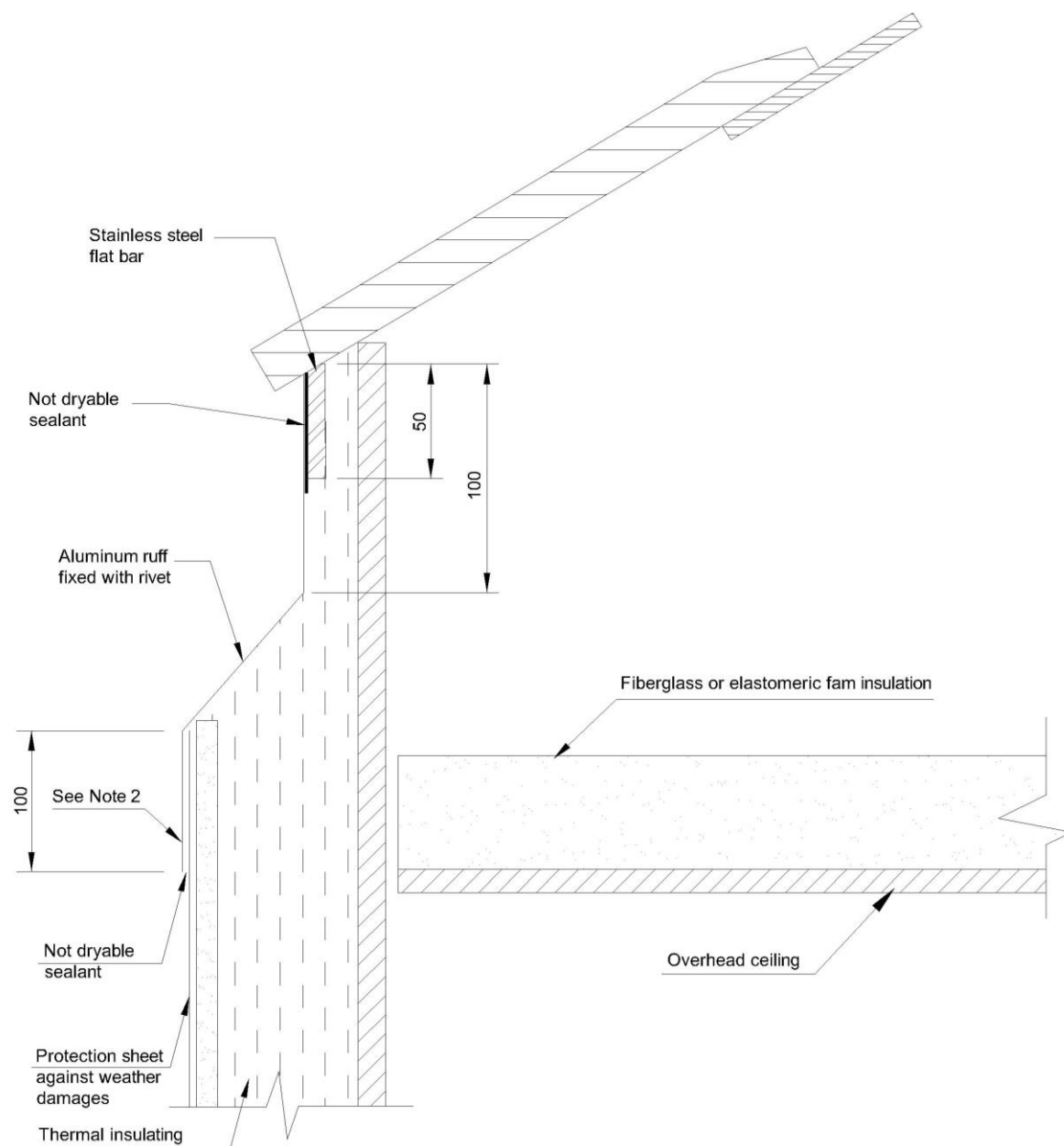
NOTE 1 Dimensions in millimeters, unless otherwise provided.

NOTE 2 The anchorage detailing of the protection sheet shall be analyzed depending on how high is the tank.

NOTE 3 This layer may also be made of an elastomeric foam with the same thickness.

**Figure A.23.1 - General Layout**

**Figure A.23 - Insulation of Tanks**



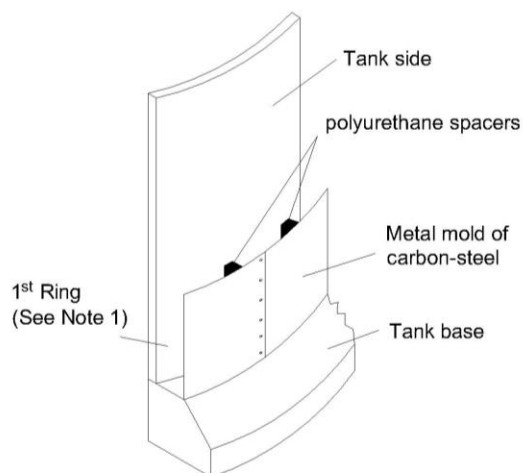
**Detail A**

NOTE 1 Dimensions in millimeters, unless otherwise provided.

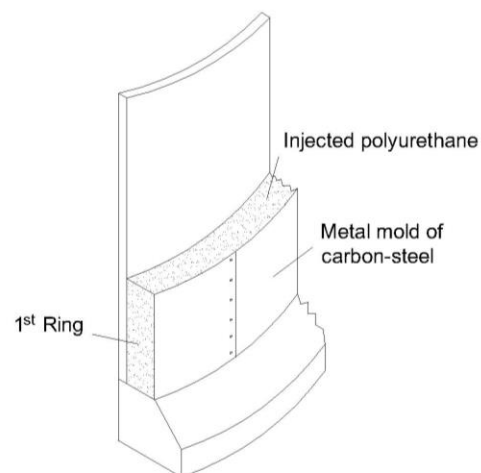
NOTE 2 Fixture of the protection sheet to the ruff with rivets.

**Figure A.23.2 - Detail of the Ceiling**

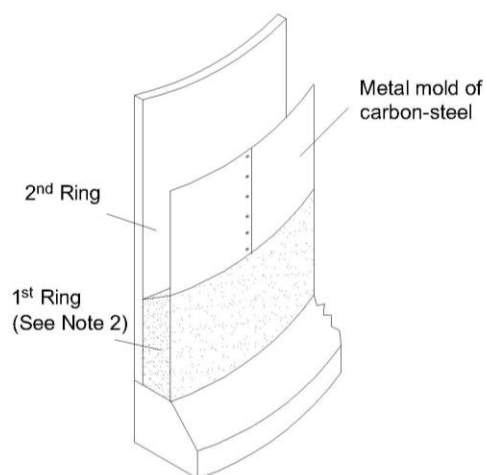
**Figure A-23 - Insulation of Tanks**



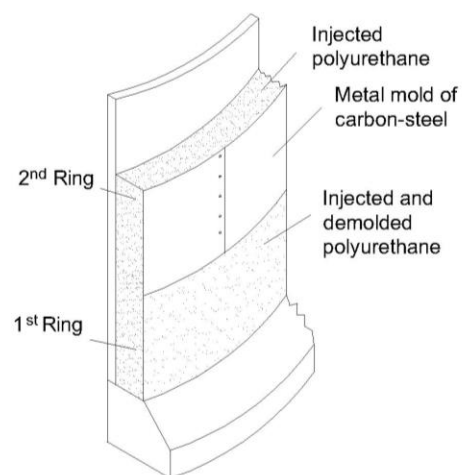
1) Installation of the metal mold in the 1<sup>st</sup> ring



2) Injection of polyurethane in the 1<sup>st</sup> ring

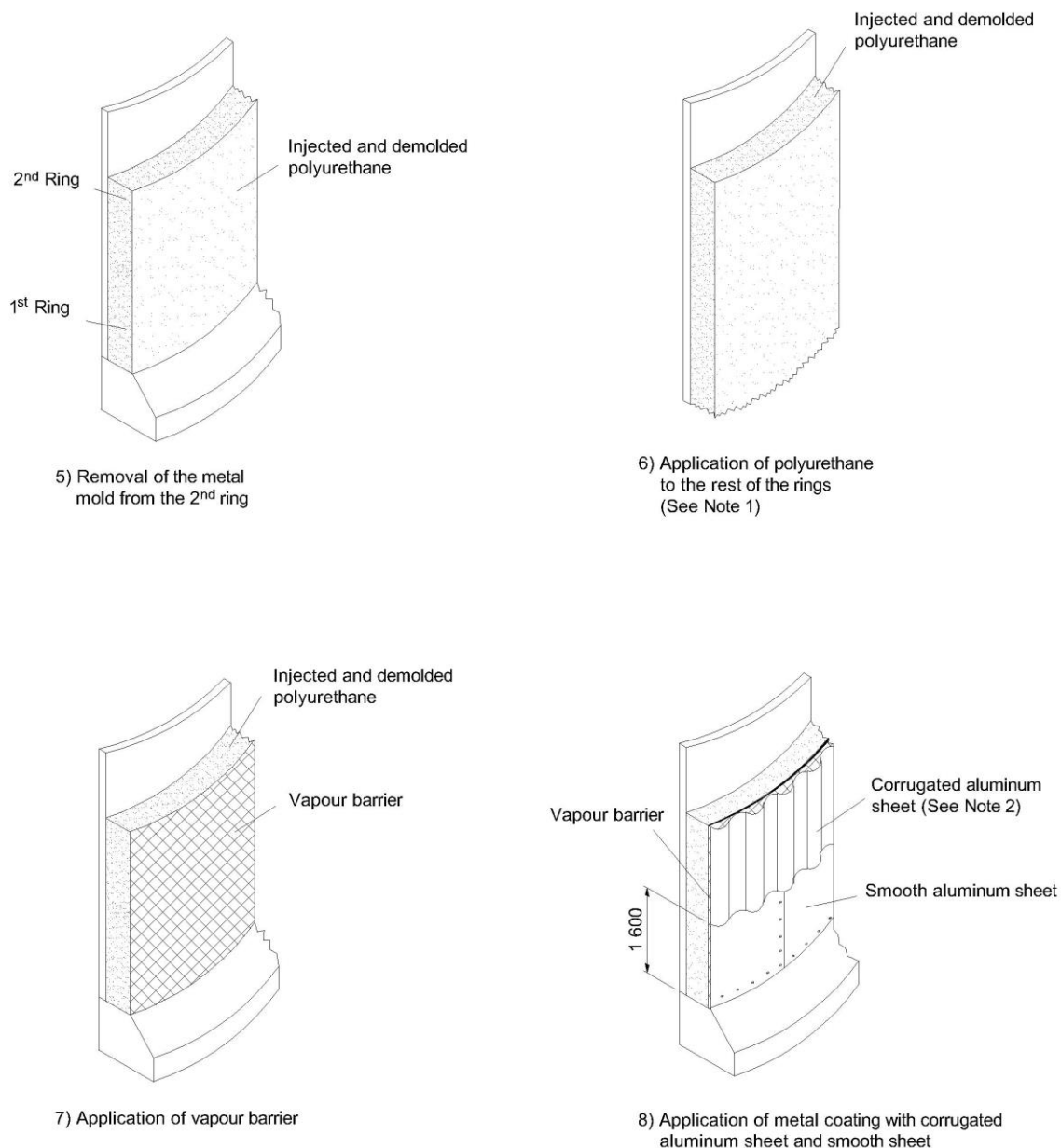


3) Cut to 45° of the overflow polyurethane, removal of the mold from the 1<sup>st</sup> ring and installation of the metal mold to the 2<sup>nd</sup> ring



4) Installation of metal mold and injection of polyurethane in the 2<sup>nd</sup> ring

**Figure A.24 - Insulation of Tanks**



NOTE 1 Approximated height of 1 m among rings.

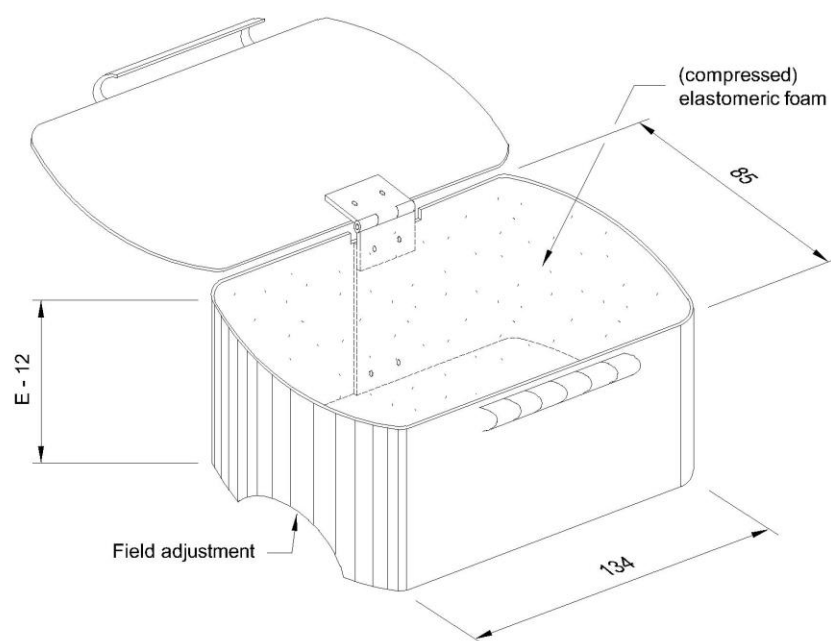
NOTE 2 The mold of the previous ring can be maintained according to the availability of plates. Keep molds on at least two rings simultaneously.

NOTE 3 Repeat steps 3 and 4 for the application of polyurethane to the rest of the rings.

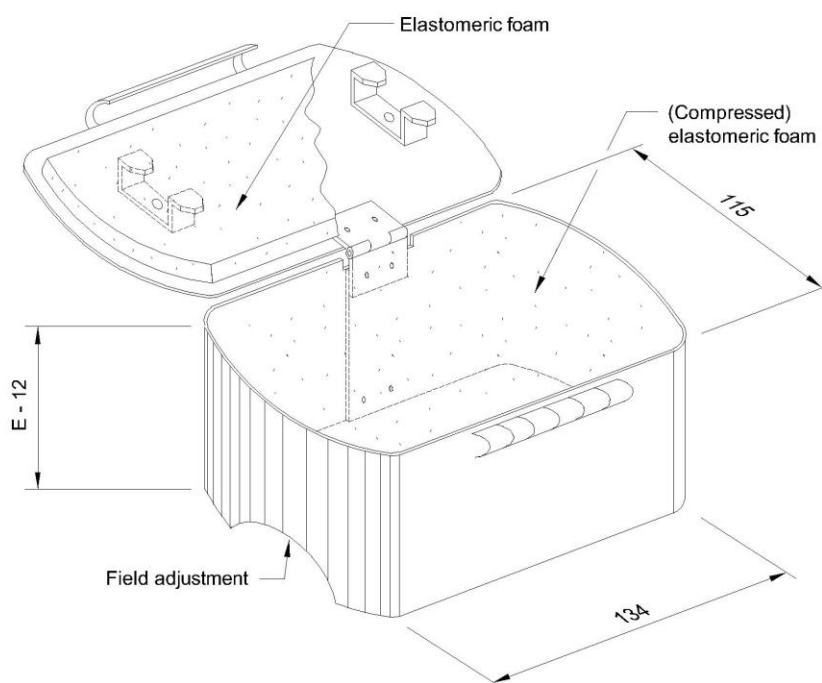
NOTE 4 The metal coating may also be made, in its entirety, with smooth aluminum sheet.

**Figure A.24 - Insulation of Tanks (Continuation)**





Box for measuring thickness in piping  
with nominal diameter up to 2 1/2"



Box for measuring thickness in piping  
with nominal diameter starting from 3"

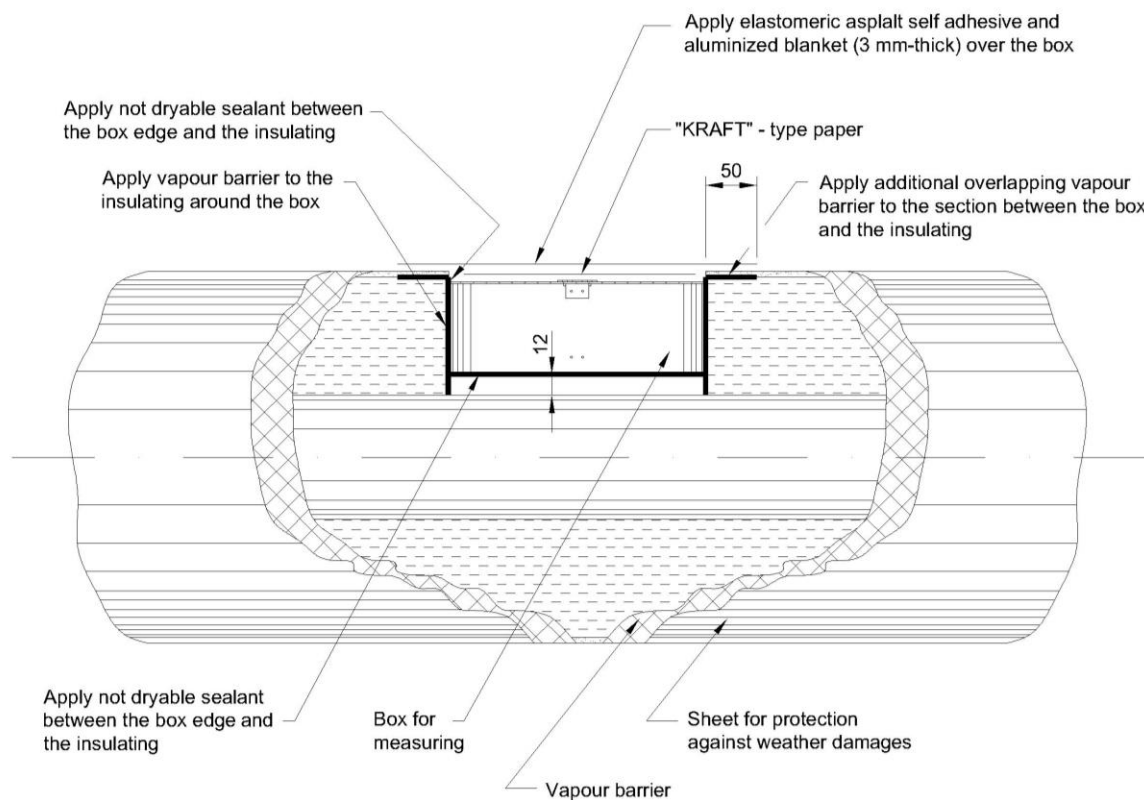
NOTE 1 Dimensions in millimeters, unless otherwise provided.

NOTE 2 1 mm-Thick aluminum sheet.

NOTE 3 E = thickness of the thermal insulation.

**Figure A 25.1 - Detail of Boxes for Periodic Measurements.**

**Figure A.25 - Boxes for Periodic Measurements**



NOTE Dimensions in millimeters, unless otherwise provided.

**Figure A.25.2 - Assembly Details**

**Figure A.25 - Boxes for Periodic Measurements**

<b>INDEX OF REVISIONS</b>	
<b>REV. A, B and C</b>	
There is no index of revisions	
<b>REV. D</b>	
<b>Affected Parts</b>	<b>Description of Alteration</b>
1	Revised
2	Revised
3	Revised
3.2 and 3.3	Eliminated
3.4	Renumbered
4.1	Revised and Renumbered
4.16.1	Revised
4.16.2	Included
4.16.3	Renumbered
4.18	Revised
5.1.4 to 5.1.9.5	Renumbered
5.2.1	Revised
5.2.5	Revised
5.2.7	Included
5.3.7 to 5.3.11	Renumbered
5.4.4	Revised
5.6.3.2 and 5.6.3.3	Revised
5.7	Revised
6	Revised
7.2.2	Included
Annex A	Revised
<b>REV. E</b>	
<b>Affected Parts</b>	<b>Description of Alteration</b>
All	Revised
<b>REV. F</b>	
<b>Affected Parts</b>	<b>Description of Alteration</b>
All	Revised