

**CONTEC**  
Comissão de Normalização  
Técnica

**SC - 09**  
Thermal Insulation and  
Refractories

## Thermal Insulation Material

### Standardization

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.

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### Introduction

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## Foreword

This Standard is the English version (issued in DECEMBER/2020) of PETROBRAS N-1618 REV. H 02/2020, 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 standardizes high and low temperature thermal insulation materials, complementary materials, and accessories used for installing thermal insulation for external use in equipment and piping.

1.2 This Standard applies to designs started as of its issuance date as well as to maintenance or refurbishing 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-1367](#) - Determinação do Teor de Sólidos por Massa em Tintas e Produtos Afins;

ABNT [NBR 5007](#) - Tiras Relaminadas de Aço de Baixo Teor de Carbono para Estampagem - Especificação;

ABNT [NBR 5601](#) - Aços Inoxidáveis - Classificação por Composição Química;

ABNT [NBR 5589](#) - Arame de Aço de Baixo Teor de Carbono - Requisitos;

ABNT [NBR 6323](#) - Galvanização por imersão a quente de produtos de aço e ferro fundido - Especificação;

ABNT [NBR 6331](#) - Arame de Aço de Baixo Teor de Carbono, Zincado, para Uso Geral - Especificação;

ABNT [NBR 7000](#) - Alumínio e suas Ligas - Produtos Extrudados com ou sem Trefilação - Propriedades Mecânicas;

ABNT [NBR 7008-2](#) - Chapas e Bobinas de Aço Revestidas com Zinco ou Liga Zinco-Ferro pelo Processo Contínuo de Imersão a Quente - Parte 2: Aços de Qualidade Comercial e para Estampagem;

ABNT [NBR 7358](#) - Espuma rígida de poliuretano para fins de isolamento térmica - Determinação das características de inflamabilidade;

ABNT [NBR 7556](#) - Alumínio e suas Ligas - Chapas - Requisitos;

ABNT [NBR 8094](#) - Material Metálico Revestido e não Revestido - Corrosão por Exposição à Nevoa Salina - Método de ensaio;

ABNT [NBR 8096](#) - Material Metálico Revestido e Não-Revestido - Corrosão por Exposição ao Dióxido de Enxofre - Método de Ensaio;

- ABNT [NBR 9688](#) - Isolantes térmicos com mantas de fibra cerâmica;
- ABNT [NBR 9909](#) - Painéis termoisolantes à base de fibra cerâmica;
- ABNT [NBR 10412](#) - Isolantes térmicos de lã de vidro feltros de lamelas - Especificação;
- ABNT [NBR 10662](#) - Isolantes térmicos pré-moldados de silicato de cálcio - Especificação;
- ABNT [NBR 11357](#) - Tubos Termoisolantes à Base de Lã de Vidro;
- ABNT [NBR 11358](#) - Painéis Termoisolantes à Base de Lã de Vidro;
- ABNT [NBR 11360](#) - Isolantes Térmicos de Lã de Vidro - Flocos - Especificação;
- ABNT [NBR 11361](#) - Mantas Termoisolantes à Base de Lã de Vidro;
- ABNT [NBR 11363](#) - Tubos Termoisolantes à Base de Lã de Rocha;
- ABNT [NBR 11364](#) - Painéis Termoisolantes à Base de Lã de Rocha - Especificação;
- ABNT [NBR 11722](#) - Feltros Termoisolantes à Base de Lã de Rocha;
- ABNT [NBR 11777](#) - Cimento Isolante à Base de Silicato de Cálcio para Rejuntamento - Especificação;
- ABNT [NBR 13047](#) - Mantas termoisolantes à base de lã de rocha;
- ABNT [NBR ISSO 18553](#) - Método para Avaliação do Grau de Dispersão de Pigmentos ou Negro-de-Fumo em Tubos, Conexões e Compostos Poliolefinicos;
- ISO [1522](#) - Paints and Varnishes - Pendulum Damping Test;
- ISO [3233-1](#) - Paints and varnishes - Determination of percentage volume of non-volatile Matter - Part 1: Method using a coated test panel to determine non-volatile matter and to determine dry-film density by the Archimedes' principle;
- ASTM [A36/A36M](#) - Standard Specification for Carbon Structural Steel;
- ASTM [A109/A109M](#) - Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled;
- ASTM [A390](#) - Standard Specification for Zinc-Coated (Galvanized) Steel Poultry Fence Fabric (Hexagonal and Straight Line);
- ASTM [A480/A480M](#) - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip;
- ASTM [A492](#) - Standard Specification for Stainless Steel Rope Wire;
- ASTM [A879/A879M](#) - Standard Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface;
- ASTM [B209](#) - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate;
- ASTM [B633](#) - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel;
- ASTM [B841](#) - Standard Specification for Electrodeposited Coatings of Zinc Nickel Alloy Deposits;
- ASTM [B849](#) - Standard Specification for Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement;

ASTM [B850](#) - Standard Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement;

ASTM [C177](#) - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus;

ASTM [C795](#) - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel;

ASTM [C552](#) - Standard Specification for Cellular Glass Thermal Insulation;

ASTM [C1728](#) - Standard Specification for Flexible Aerogel Insulation;

ASTM [D543](#) - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents;

ASTM [D635](#) - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position;

ASTM [D638](#) - Standard Test Method for Tensile Properties of Plastics;

ASTM [D790](#) - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials;

ASTM [D1238](#) - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer;

ASTM [D1505](#) - Standard Test Method for Density of Plastics by the Density-Gradient Technique;

ASTM [D1525](#) - Standard Test Method for Vicat Softening Temperature of Plastics;

ASTM [D1621](#) - Standard Test Method for Compressive Properties of Rigid Cellular Plastics;

ASTM [D1622/D1622M](#) - Standard Test Method for Apparent Density of Rigid Cellular Plastics;

ASTM [D1623](#) - Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics;

ASTM [D1754/D1754M](#) - Standard Test Method for Effect of Heat and Air on Asphaltic Materials (Thin-Film Oven Test);

ASTM [D2042](#) - Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene;

ASTM [D2126](#) - Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging;

ASTM [D2240](#) - Standard Test Method for Rubber Property-Durometer Hardness;

ASTM [D2244](#) - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates;

ASTM [D2247](#) - Standard Practice for Testing Water Resistance of Coating in 100 % Relative Humidity;

ASTM [D2794](#) - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact);

ASTM [D2842](#) - Standard Test Method for Water Absorption of Rigid Cellular Plastics;

ASTM [D3349](#) - Standard Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black;

ASTM [D3359](#) - Standard Test Methods for Measuring Adhesion by Tape Test;

ASTM [D4141](#) - Standard Practice for Conducting Black Box and Solar Concentrating Exposures of Coatings;

ASTM [D4218](#) - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique;

ASTM [D6226](#) - Standard Test Method for Open Cell Content of Rigid Cellular Plastics;

ASTM [E313](#) - Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates;

ASTM [G155](#) - Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials.

### **3 Terms and Definitions**

For the purposes of this document the following terms and definitions are applied.

#### **3.1**

##### **rigid thermal insulation**

pre-molded pieces supplied in the form of segments, half sections, boards, and special parts and made of the following insulating materials:

- a) calcium silicate;
- b) rigid polyurethane and polyisocyanurate foam;
- c) expanded perlite;
- d) cellular glass.

#### **3.2**

##### **flexible thermal insulation**

flexible pieces supplied in the form of felts, panels, flexible pipes, blankets, flakes, cords, and modules and made of the following insulating materials:

- a) glass wool;
- b) rock wool;
- c) ceramic wool or fiber;
- d) aerogel;
- e) elastomeric foam.

#### **3.3**

##### **complementary material**

material used to protect the thermal insulation and/or to install the vapor barrier, such as: cements mastics, sealants, protective coatings.

#### **3.4**

##### **accessory**

material used to facilitate the installation and to fix the insulating and complementary materials, such as: wires, bands, clips, seals, screws.



**3.5****high temperature**

all operating temperature above the mean of the maximum ambient temperatures during the two hottest months of the year.

**3.6****low temperature**

all operating temperature equal or below the mean of the maximum ambient temperatures during the two hottest months of the year.

**4 Rigid Thermal Insulation**

When the thermal insulation were applied on equipment or piping made of stainless steel, series 300 and 400, the maximum chloride and fluoride content in the insulation shall be in accordance with the criteria set out in ASTM [C795](#).

**4.1 Calcium Silicate**

The required characteristics are those specified in ABNT [NBR 10662](#), Type I (27 °C a 650 °C).

**4.2 Rigid Polyurethane (PUR) and Polyisocyanurate (PIR) Foam****4.2.1 Pre-Molded (in Half Sections, Segment and Plate) and Injected Polyurethane**

The required characteristics are those specified in ABNT [NBR 11726](#), with the following additional requirements:

- a) with flame retarding agents (except for using in pipelines and buried pipes);
- b) expanding agent free of CFC gas (chlorofluorocarbon);
- c) properties as per Table 1.

**Table 1 – Characteristics of Pre-Molded and Injected Polyurethane**

Properties	Unity	Type 1 (-10 °C a 70 °C)	Type 2 (-40 °C a 80 °C)	Type 3 (-120 °C a 90 °C)	Test Method
Apparent density	kg/m <sup>3</sup>	20 a 30	> 30 a 40	> 40 a 65	ASTM <a href="#">D1622</a>
Maximum thermal conductivity at 23 °C	W/m.K	0,023	0,023	0,023	ASTM <a href="#">C177</a>
Minimum Compressive strength at 10% of deformation	kgf/cm <sup>2</sup>	0,5 a 2,5	1,5 a 3,5	2,0 a 6,0	ASTM <a href="#">D1621</a>
Maximum water absorption	%-v	10	5,0	4,0	ASTM <a href="#">D2842</a>
Minimum bending resistance	kgf/cm <sup>2</sup>	1,0	1,2	2,0	ASTM <a href="#">D790</a>
Maximum linear variation (after 7 days at maximum operating temperature)	%	2,0	3,0	3,0	ASTM <a href="#">D2126</a>
Closed Cells (minimum.)	%-v	85	90	90	ASTM <a href="#">D6226</a>
Inflammability	-	Classe R 1	Classe R 1	Classe R 1	ABNT <a href="#">NBR 7358</a>
Solvents Resistance	%	10	5,0	5,0	ASTM <a href="#">D543</a>

#### 4.2.2 Sprayed Polyurethane

The required characteristics are those specified in ASTM [C1029](#), with the following additional requirements:

- a) with flame retarding agents;
- b) expanding agent free of CFC gas;
- c) characteristics according to Table 2.

**Table 2 - Characteristics of Sprayed Polyurethane**

Properties	Conditions	Units	Values			Test method
Apparent density	-	kg/m <sup>3</sup>	35/45	48/60	90/120	ASTM <a href="#">D1622</a>
Maximum thermal conductivity at 24 °C	up to 24 h	W/m.K	0,014	0,015	0,018	ASTM <a href="#">C518</a> or ASTM <a href="#">C177</a>
	after 30 d	W/m.K	0,015	0,016	0,020	
Water absorption	maximum	g/cm <sup>2</sup>	0,024	0.021	0,018	ASTM <a href="#">D2842</a>
Number of closed cells	minimum	%	90	92	95	ASTM <a href="#">D6226</a>
Maximum linear variation	7 d/70 °C	%	2	3	3	ASTM <a href="#">D2126</a>
Compressive strength	minimum	kPa	200	250	700	ASTM <a href="#">D1621</a>
Tensile strength	minimum	kPa	280	300	800	ASTM <a href="#">D1623</a>
Bending resistance	minimum	kPa	280	300	800	ASTM <a href="#">D790</a>

#### 4.2.3 Pre-molded Polyisocyanurate (in Half Sections, Segment and Plate)

The required characteristics are those listed in ASTM [C591](#), Grade 2 (-183 °C up to 149 °C), admitting Type I (≥ 137 kPa) to Type VI (≥ 862 kPa).

#### 4.3 Expanded Perlite (in Half Sections, Segment and Plate)

The required characteristics are those listed in ASTM [C610](#) (27 °C up to 649 °C).

#### 4.4 Cellular Glass(in Half Sections, Segment and Plate)

The required characteristics are those contained in ASTM [C552](#), admitting the following types:

- a) *Type I* (blocks): *Grade 6* (≥ 414 kPa) up to 24 (≥ 1 655 kPa);
- b) *Type II* (half sections or segments manufactured from *Type I*, *Grade 6*);
- c) *Type III* (special formats manufactured from *Type I*, *Grade 6*); and
- d) *Type IV* (plates manufactured from do *Type I*, *Grade 6*).

### 5 Flexible Thermal Insulation

When the thermal insulation were applied on equipment or piping made of stainless steel, series 300 and 400, the maximum chloride and fluoride content in the insulation shall be in accordance with the criteria set out in ASTM [C795](#).

## 5.1 Glass Wool

### 5.1.1 In Thin Felt Sheets

The required characteristics are those specified in ABNT [NBR 10412](#).

### 5.1.2 In Panel

The required characteristics are those specified in ABNT [NBR 11358](#), for densities of 40 kg/m<sup>3</sup> or 60 kg/m<sup>3</sup>.

NOTE consider the maximum continuous use temperature of 350 ° C for the density of 40 kg / m<sup>3</sup>, and of 450 ° C for 60 kg / m<sup>3</sup>.

### 5.1.3 In Tubular Form

The required characteristics are those specified in ABNT [NBR 11357](#).

NOTE consider typical density from 60 kg/m<sup>3</sup> to 100 kg/m<sup>3</sup> and maximum continuous use temperature of 450 °C.

### 5.1.4 In Blanket

The required characteristics are those specified in ABNT [NBR 11361](#).

NOTE consider the maximum continuous use temperature of 350 ° C for the density of 40 kg/m<sup>3</sup>, and of 450 ° C for 60 kg / m<sup>3</sup>.

### 5.1.5 In Flakes

The required characteristics are those specified in ABNT [NBR 11360](#), Class A (-30 °C a 250 °C) or Class B (-200 °C a 550 °C).

## 5.2 Rock Wool

### 5.2.1 In Thin Felt Sheets

The panels to be used to build thin felt sheet segments shall be in accordance with ABNT [NBR 11364](#), for densities of 64 kg/m<sup>3</sup>, 96 kg/m<sup>3</sup> or 128 kg/m<sup>3</sup>, and shall be supported with aluminum foil, with a minimum thickness of 0.015 mm, with or without "Kraft" paper, reinforced with polyester or glass threads.

NOTE consider the following maximum continuous use temperature:

- density of 64 kg/m<sup>3</sup>: 175 °C;
- density of 96 kg/m<sup>3</sup>: 350 °C; and
- density of 128 kg/m<sup>3</sup>: 600 °C.

### 5.2.2 In Panel

The required characteristics are those specified in ABNT [NBR 11364](#), for densities of 64 kg/m<sup>3</sup>, 96 kg/m<sup>3</sup> or 128 kg/m<sup>3</sup>

NOTE consider the following maximum continuous use temperature:

- density of 64 kg/m<sup>3</sup>: 175 °C ;
- density of 96 kg/m<sup>3</sup>: 350 °C; and
- density of 128 kg/m<sup>3</sup>: 600 °C.

### 5.2.3 In Tubular Form

The required characteristics are those specified in ABNT [NBR 11363](#).

NOTE consider the maximum continuous use temperature of 600 °C and usual density from 120 kg/m<sup>3</sup> to 165 kg/m<sup>3</sup>.

### 5.2.4 In Blankets with a Metal Mesh Support

The required characteristics are those contained in ABNT [NBR 13047](#), for densities of 64 kg/m<sup>3</sup>, 96 kg/m<sup>3</sup> or 128 kg/m<sup>3</sup>.

NOTE consider the following maximum continuous use temperature:

- density of 64 kg/m<sup>3</sup>: 175 °C
- density of 96 kg/m<sup>3</sup>: 350 °C; and
- density of 128 kg/m<sup>3</sup>: 600 °C

## 5.3 Ceramic Fiber

### 5.3.1 In Blanket

The required characteristics are those specified in ABNT [NBR 9688](#), Class C (up to 815 °C), for densities of 64 kg/m<sup>3</sup> or 96 kg/m<sup>3</sup>

NOTE consider the specification of thermal conductivity up to a temperature of 427 ° C (measured according to ASTM C177).

### 5.3.2 In Panel

The required characteristics are those specified in ABNT [NBR 9909](#), Class C (up to 815 °C), for densities of 64 kg/m<sup>3</sup> or 96 kg/m<sup>3</sup>.

NOTE consider the specification of thermal conductivity up to a temperature of 427 ° C (measured according to ASTM C177).

### 5.3.3 In Modules

Ceramic Fiber Module, anchored with metallic fix system, required characteristics as per ABNT NBR 9688 (were applicable), Class A (up to 1 260 °C), for densities of 96 kg/m<sup>3</sup> or 128 kg/m<sup>3</sup>.

NOTE consider the specification of thermal conductivity up to a temperature of 427 ° C (measured according to ASTM C177).

### 5.3.4 In Cords

The required characteristics are:

- a) density: 320 kg/m<sup>3</sup> to 700 kg/m<sup>3</sup>;
- b) continuous use temperature: minimum 1 090 °C;
- c) the fibers can be composed by metallic oxides of, but not limited to, aluminum (Al<sub>2</sub>O<sub>3</sub>), silicon (SiO<sub>2</sub>), calcium (CaO) and magnesium (MgO);
- d) diameters: 9 mm to 51 mm.

## 5.4 Aerogel (In Blanket)

The required characteristics are those specified in ASTM [C1728](#), being admitted the following types:

- a) Type I (-196 °C up to 125 °C), *Grade 1B* ( $\geq 34,5$  kPa);
- b) Type III (24 °C up to 649 °C), *Grade 1A* (flat surface); and
- c) Type III (24 °C up to 649 °C), *Grade 2A* (pipes).

## 5.5 Elastomeric Foam (In Tubular Form and Blanket)

The required characteristics are those specified in ASTM [C534/C534M](#), being admitted the following types:

- a) Type I (pipe): *Grade 1* (-183 °C up to 104 °C), *Grade 2* (-183 °C up to 150 °C) and *Grade 3* (-183 °C a 120 °C, free of chlorides, fluorides or PVC); and
- b) Type II (blanket): *Grade 1* (-183 °C up to 104 °C), *Grade 2* (-183 °C up to 150 °C) and *Grade 3* (-183 °C up to 120 °C, free of chlorides, fluorides or PVC).

## 6 Complementary Materials

### 6.1 Insulating Cement

#### 6.1.1 To Calcium Silicate

The required characteristics are those specified in ABNT [NBR 11777](#), with the following additional requirements:

- a) free of asbestos;
- b) for average temperature of 95 °C consider the maximum thermal conductivity of 0,317 W/m.K;
- c) maximum chloride and fluoride content shall meet to the ASTM [C795](#) criteria for stainless steel equipment or piping by series 300 and 400.

#### 6.1.2 To Expanded Perlite

The required characteristics shall meet the manufactory recommendations.

### 6.2 Asphalt-Based Finish Mastic

6.2.1 Composed of asphalt emulsion resistant to weathering conditions, containing reinforcement fibers, free of asbestos, shall not containing sand or diatomaceous, it must be elastic and present, when applied and dry, a smooth and uniform surface, without cracking and granules.

6.2.2 The required characteristics are those specified in Table 2, shall be used in the range from 18 °C to 93 °C.

**Table 3 - Physical Requirements of Asphalt-Based Finish Mastic**

Characteristics	Unit	Value	Test Method
Minimum apparent density	kg/m <sup>3</sup>	1 200	ASTM <a href="#">D70</a>
Mechanical tensile strength in longitudinal and transversal directions (minimum).	N/cm (kgf/cm)	50 (5)	ASTM <a href="#">D146/D146M</a> (test specimen thickness: 3,2 mm)
Minimum total solids	%	70	PETROBRAS <a href="#">N-1367</a>
Maximum linear contraction of wet layer after drying.	%	4	See Note 2

**Table 3 - Physical Requirements of Asphalt-Based Finish Mastic (Continuing)**

Characteristics	Unit	Value	Test Method
Maximum thickness reduction of wet layer after drying.	%	50	See Note 2
Maximum mass variation by water absorption; 100 % immersed for 24 hours at 25 °C.	%	12	ASTM <a href="#">D471</a> (test specimen thickness 3.2 mm)
Maximum dry to touch time at a temperature of 23 °C.	hour	7	ASTM <a href="#">C461</a> (checks every 15 minutes)
Fire test.	-	Should not be seen bleeding of oily material at the area contacted by the flame as run-down.	<ul style="list-style-type: none"> <li>- Mount the test specimen (see Note 1) in a vertical position and subject them to the blue flame of a "Bunsen" applied at the center of the coated area for exactly 10 s. Remove the test specimen from the flame and after 10 s should not have any continued combustion of the coating.</li> <li>- Again apply the flame of the "Bunsen" continuously to the center of the coated area, and make observations for slipping, run-down, or loss or charred material from the mastic applied to test panel during the direct flame test.</li> <li>- Do not consider slight bleeding of oily material at the area contacted by the flame as run-down.</li> </ul>
Minimum elongation.	%	2	ASTM <a href="#">D113</a>

NOTE 1 When not indicated in the test method, test specimens shall be prepared as described below:

- apply asphalt mastic on a metal panel, with 150 mm<sup>2</sup> in area and 0,30 to 0,40 mm thick;
- asphalt mastic shall be applied using a spatula, always in a single spreading direction, through a mask, 1,6 mm thick, with a centralized hole of 100 mm<sup>2</sup> in area;
- dry at ambient temperature;

NOTE 2 Linear contraction and thickness reduction tests shall be performed according to the following procedure:

- apply sample in an impermeable mold of 100 mm x 50 mm x 6 mm ± 1 mm using a spatula, until a uniform finish is obtained;
- remove the mold right after the asphalt mastic becomes consistent;
- perform 6 measurements on the largest dimension of the test specimen at equidistant points and 12 thickness measurements, 3 on each side, 12 mm from the edges;
- allow test specimen to dry at ambient temperature;
- perform once again the same measurements at the same points;
- calculate linear shrinkage using the following formula:

$$CL = \frac{Li - Lf}{Li} \cdot 100$$

Where:

CL linear shrinkage after drying, in %;

Li arithmetic average of 6 initial specimen length measurements, in mm;

Lf arithmetic average of 6 final specimen length measurements, in mm.

- calculate thickness reduction using the following formula:

$$RE = \frac{Ei - Ef}{Ei} \cdot 100$$

Where:

RE is the thickness reduction, in %;

Ei is the arithmetic average of 12 initial specimen thickness measurements, in mm;

Ef is the arithmetic average of 12 final specimen thickness measurements, in mm.

### **6.3 Sealant**

#### **6.3.1 Non dryable**

The base composition is silicone rubber and the operation temperature between -65 °C and 260 °C.

#### **6.3.2 Dryable**

The base composition is asphalt or elastomeric, with the following main characteristics:

- a) temperature of continuous use between -70 °C and 60 °C for elastomeric base and between -20 °C and 60 °C for asphalt base, remaining flexible and adherent within such temperature ranges;
- b) volatile material  $\leq 5 \%$ ;
- c) retraction caused by drying  $\leq 5 \%$ ;
- d) constant resilience;
- e) flame shall not be kept for more than 2 minutes, when exposed to a Bunsen burner flame for 3 minutes;
- f) shall be chemically compatible with polyurethane materials (see item 4.2).

### **6.4 Waterproofing material of Asphalt or Elastomeric Base**

6.4.1 Waterproofing material of the asphalt or elastomeric base or composed of polyurethane with asphalt shall be chemically compatible with the insulating materials used.

6.4.2 The continuous temperature of use shall be within the following ranges:

- a) asphalt base material: -20 °C to 50 °C;
- b) elastomeric base material: -35 °C to 80 °C;

6.4.3 The minimum percentage of solids shall be 50 % in volume, according to PETROBRAS [N-1358](#).

6.4.4 The flexibility shall be in a way that not cause cracks when a 0,75 mm thickness film is folded, with an arc of 120° over an mandrel of 3 mm of diameter.

6.4.5 The consistence shall be compatible with the application method used.

6.4.6 The dry to touch time shall be maximum 4 h.

6.4.7 The waterproofing materials shall be self-extinguishing, black color, with minimum emissivity of 0,90 or admit application of painting system in black color.

### **6.5 Adhesive of Asphalt or Elastomeric Base**

6.5.1 The adhesive of asphalt or elastomeric base adhesives shall be chemically compatible with the insulating materials used.

6.5.2 The temperatures of continuous use shall be within the following ranges:

- a) asphalt base materials: -20 °C to 50 °C;
- b) elastomeric base materials: -35 °C to 80 °C.

6.5.3 The consistence shall allow brush application.

6.5.4 The maximum curing time for polymeric adhesive shall be 10 min.

6.5.5 The softening point of asphalt base adhesive, determined by ASTM [D36/D36M](#), shall be between 50 °C and 110 °C.

6.5.6 The maximum hardening time for asphalt base adhesive, after the heat source is removed, shall be 5 min.

6.5.7 The flash point of the asphalt base adhesive determined by ASTM [D92](#) shall be 150 °C.

6.5.8 The adhesive shall not soften or lose its adhesiveness within the range of the temperature of continuous use.

## **6.6 Hexagonal Reinforcement Wire Mesh**

Constituted of diameter wire of 0,56 mm to 0,86 mm (24 to 20 BWG), mesh of 12 mm or 25 mm, and material of carbon steel SAE 1 010 or 1 020 galvanized, according to the ASTM [A390](#), Class 1, or stainless steel according to ASTM [A492](#), type 304 or 316.

## **6.7 Asphalt Felt**

Material consisting of mineral or vegetable fibers, impregnated up to the saturation with asphalt. The asphalt felt shall have a smooth texture and meet the requirements of ABNT [NBR 9228](#).

**NOTE** In the case of mineral fibers felt, may be utilized reinforcing of polyethylene film, fiberglass, polyester fiber or combinations of more than one material.

## **6.8 Protective Covering**

### **6.8.1 Aluminum Sheet**

The classification and characteristics required are:

- a) class A (smooth sheet), type I (with barrier against condensation), with a width of 1 000 mm or 1 200 mm and thicknesses of 0,5 mm, 0,8 mm or 1 mm;
- b) class A (smooth sheet), type II (without barrier against condensation), with a width of 1 000 mm or 1 200 mm and thicknesses of 0,5 mm, 0,8 mm or 1 mm;
- c) class B (corrugated sheet), type I (with barrier against condensation), with a width of 910 mm, corrugation amplitude of 8 mm  $\pm$  10 %, corrugation height of 1,1 mm  $\pm$  10 % and thicknesses of 0,15 mm or 0,40 mm;
- d) class B (corrugated sheet), type II (without a barrier against condensation), with a width of 910 mm, corrugation amplitude of 8 mm  $\pm$  10 %, corrugation height of 1,1 mm  $\pm$  10 % and thicknesses of 0,15 mm or 0,40 mm.



6.8.1.1 The barrier against condensation shall be of the asphalt type: constituting of two sheets of pure virgin Kraft paper, of 40 g/m<sup>2</sup> each, between which, a layer of asphalt, with a minimum softening point of 80 °C, neutralized, considering a quantity of 30 g/m<sup>2</sup>, is applied.

6.8.1.2 The aluminum sheet alloys shall be in 3 003 or 5 005 (hardness H14 or H16), according to specification ABNT [NBR 7556](#).

## **6.8.2 Pre-painted Galvanized Carbon Steel Sheet**

6.8.2.1 The base sheet shall be in accordance with ABNT [NBR 7008-2](#), grade ZC, coating Z275 and finishing surface of normal (N) crystal type with quality "Surface 2". Sheet thickness shall be of 0,30 mm to 0,50 mm. The characteristics of the paint system shall be in accordance with Table 4.

**Table 4 - Paint System**

<b>Properties</b>	<b>Value</b>	<b>Standard</b>
Resistance to weathering	960 h	ASTM <a href="#">D4141</a>
Resistance in salt chamber	1 000 h	ABNT <a href="#">NBR 8094</a>
Impact resistance	160 in.lb (without fracture)	ASTM <a href="#">D2794</a>
SO <sub>2</sub> resistance	5 rounds	ABNT <a href="#">NBR 8096</a>
Moisture/condensation resistance	960 h	ASTM <a href="#">D2247</a>
Surface hardness	minimum 130 "könig"	ISO <a href="#">1522</a>
Flexibility to fold over itself	20 % to 30 % of elongation	ASTM <a href="#">D522</a>
Adhesion	60 % (white face)	ASTM <a href="#">D523</a>
	minimum grade 4, method B	ASTM <a href="#">D3359</a>

6.8.2.2 One of the sheet faces shall be painted white.

## **6.8.3 Aluminum Roofing**

### **6.8.3.1 Trapezoidal Type**

Aluminum roofing made of 3 003 or 5 005 (hardness H14 or H16) alloy, according to ASTM [B209](#), trapezoidal type, 1 056 mm wide, 3 140 mm long, 0,8 mm thick, and weighing 2,565 kg/m<sup>2</sup>.

### **6.8.3.2 Wavy Type**

Aluminum roofing made of 3 003 or 5 005 (hardness H14 or H16) alloy, according to ASTM [B209](#), wavy type, 1 120 mm wide, 3 000 mm long, 0,8 mm thick, 76 mm pitch and 17 mm wave height.

## **6.8.4 Rigid Pipe**

### **6.8.4.1 Extruded Aluminum**

According to ABNT [NBR 7000](#).

### **6.8.4.2 High Density Polyethylene (HDPE)**

According to Table 5.

**Table 5 - Characteristics of Polyethylene**

Properties	Conditions	Units	Values	Test Method
Apparent density	-	g/cm <sup>3</sup>	0,918 to 0,938	ASTM <a href="#">D1505</a>
Carbon black content (see Note 1)	-	%	2,0 to 2,8	ASTM <a href="#">D4218</a>
Carbon black dispersion (see Note 1)	-	photographic standard	photos a or b	ABNT <a href="#">NBR ISO 18553</a>
UV (ultraviolet) absorption coefficient (see Note 1)	-	Abs/cm	≥ 3 000	ASTM <a href="#">D3349</a>
Fluidity index	190 °C/2,16 kg	g/10 min	0,13 to 0,55	ASTM <a href="#">D1238</a>
Tensile Strength at Break (see Note 2)	at 23 °C	MPa	> 10	ASTM <a href="#">D638</a>
Strain deformation (see Note 2)	at 23 °C	MPa	> 9.7	ASTM <a href="#">D638</a>
Elongation at break (see Note 2)	at 23 °C	%	> 500	ASTM <a href="#">D638</a>
Hardness	-	Shore D	> 45	ASTM <a href="#">D2240</a>
Softening temperature vicat (VST)	-	°C	> 90	ASTM <a href="#">D1525</a>
NOTE 1 Tests required only for piping exposed for more than 6 months to ultraviolet radiation.				
NOTE 2 Type IV test specimen with traction speed of 50 mm/min.				

**6.8.4.3 Glass Fiber Reinforced Plastic**

The characteristics of reinforced plastic shall conform to Table 6.

**Table 6 - Characteristics of Glass Fiber Reinforced Plastic**

Properties	Value	Standard
Flammability	Burning time < 10 s Burning extension < 15 mm	ASTM <a href="#">D635</a>
Water absorption	Increase in mass < 0,1 g / 100 cm <sup>2</sup>	ASTM <a href="#">D570</a>
Resistance to inorganic fluids (HCl, H <sub>2</sub> SO <sub>4</sub> , H <sub>3</sub> PO <sub>4</sub> , NaOH)	Increase in mass < 0,1 g / 100 cm <sup>2</sup>	ASTM <a href="#">D543</a>
Resistance to organic fluids (ethyl alcohol, glacial acetic acid, yellow gasoline, kerosene, ethylene glycol)	Increase in mass < 0,5 g / 100 cm <sup>2</sup>	ASTM <a href="#">D543</a>
Ageing - 1 000 h	<ul style="list-style-type: none"> <li>It shall not have any surface changes (cracks, spots, delamination, yellowness or fiber exposure) after 1 000 h of exposure;</li> <li>Yellowness index variation ≤ + 30;</li> <li>Specular gloss reduction ≤ 15 UB (reference specular gloss of material ≥ 60 UB)</li> <li>Bending resistance after 1 000 h of aging; max. 20 % less relating to sample before aging (reference value = 120 MPa)</li> </ul>	ASTM <a href="#">G155</a> ASTM <a href="#">D2244</a> ASTM <a href="#">E313</a> ASTM <a href="#">D523</a> ASTM <a href="#">D790</a>

### 6.8.5 Curve or Tee shaped

6.8.5.1 90° curve (long or short radius) or 45 ° (long radius) split, for diameters between NPS ½ to 12, made of 0.6 mm thick smooth (shaped) aluminum plate, according to ASTM C1729 Grade 3 (alloy 1 100 annealed), Type I (without external surface finish) or Type III (coated with pigment-free paint), Class D (with painted vapor barrier).

6.8.5.2 Bipartite tee, made of 0.6 mm thick (conformed) flat aluminum plate, according to ASTM C1729 Grade 3 (annealed 1 100 alloy), Type I (without surface finish) or Type III (coated with pigment-free paint), Class D (with painted vapor barrier).

### 6.9 Oxidized Asphalt

The characteristics of oxidized asphalt shall be in accordance with Table 7.

**Table 7 - Characteristics of Oxidized Asphalt**

Properties	Value	Standard
Softening point (ring ball)	from 75 °C to 100 °C	ASTM <a href="#">D36/D36M</a>
Flash point	220 °C (minimum)	ASTM <a href="#">D92</a>
Ductility, at 25 °C	3 cm (minimum)	ASTM <a href="#">D113</a>
Solubility in trichloroethylene	99 % (minimum)	ASTM <a href="#">D2042</a>
Loss due to heating at 163 °C, 5 hours	0.3 %	ASTM <a href="#">D1754/D1754M</a>
Density	1.01 to 1.05	ASTM <a href="#">D71</a>
Penetration measured at 25 °C, 100 g, 5 seconds	20 to 40 tenth of mm	ASTM <a href="#">D5/D5M</a>

### 6.10 Thick Crushed Stone

Diameter from 2,00 mm to 4,80 mm, free of substances that might change the aesthetic appearance of the protection sheets of the insulating material used on the shell. Example: ferrous compounds.

### 6.11 Bitumen Kraft Paper

It shall present a density of 110 g/m<sup>2</sup> and be comprised of 2 sheets of 40 g/m<sup>2</sup> with 30 g/m<sup>2</sup> of bitumen between them.

## 7 Accessories

### 7.1 Fastening Wire

7.1.1 Galvanized steel wire according to ABNT [NBR 5589](#), soft, nominal diameter of 1,25 mm (BWG 18), light zinc layer according to ABNT [NBR 6331](#).

7.1.2 Stainless steel wire, according to ABNT [NBR 8635](#), type 304 or 316, diameter of 1,20 mm.

## 7.2 Securing Band and Tape

7.2.1 Re-rolled strip band of low carbon steel content, according to ABNT [NBR 5007](#), grade G3, Class RL, surface C, matte finish, and thickness of 0,50 mm, width of 12,7 mm, galvanized according to ABNT [NBR 6323](#), average coating thickness of 50  $\mu\text{m}$  (350 g/m<sup>2</sup>).

7.2.2 Strip band of aluminum alloy 3 003 or 5 005, according to ASTM [B209](#), hardness H-14 to H-19, width of 12,7 mm or 19 mm and thickness of 0,50 mm.

7.2.3 Strip band of stainless steel type 304 or 316, according to ASTM [A167](#) and [A480/A480M](#), width of 12,7 mm or 19 mm and thickness of 0,50 mm.

7.2.4 Filamentous polyester adhesive tape reinforced with "rayon" fibers, width of 25 mm, thickness of 0,24 mm, with adhesion on stainless steel sheet of 1 kgf/25 mm, minimum tensile strength of 60 kgf/25 mm and maximum elongation at rupture of 30 %.

7.2.5 Acrylic foam tape covered on both sides with acrylic adhesive and polyethylene film in order to protect the adhesive layer. Basic dimensions: width of 25 mm, thickness of 1,2 mm and density of 770 kg/m<sup>3</sup>.

## 7.3 Spring

### 7.3.1 Sinusoidal Spring

Spring of carbon steel SAE 1 050, galvanized according to ASTM [A879/A879M](#), wave length of 45 mm, wave amplitude of 25 mm, wire diameter of 3 mm, according to Figure A.1 of Annex A and with a spring constant of 5,2 N/m (0,53 kgf/mm)  $\pm$  10 %.

### 7.3.2 Helical Spring

Spring of carbon steel SAE 1 050, galvanized according to ASTM [A879/A879M](#), or stainless steel 304 or 316, outside diameter of 12,7 mm; wire diameter of 2,5 mm; useful length of 152 mm; approximate total length of 185 mm; spring constant of 7,4 N/m (0,75 kgf/mm)  $\pm$  10 %; according to Figure A.2 of Annex A.

## 7.4 Seal

7.4.1 Carbon steel seal SAE 1 010, according to ASTM [A109/A109M](#), galvanized, according to ASTM [B633](#), finish Type II, zinc layer thickness of 12 micrometers, width of 12,7 mm and thickness of 1,0 mm, according to Figure A.3 of Annex A.

7.4.2 Seal of aluminum alloy 3 003 or 5 005, according to ASTM [B209](#), hardness H-14 to H-19 in the widths of 12,7 mm or 19 mm and thickness of 1,0 mm, according to Figure A.3 of Annex A.

7.4.3 Stainless steel seal type 304 or 316, according to ASTM [A167](#) and [A480](#), width of 12,7 mm or 19 mm and with a thickness of 1,0 mm, according to Figure A.3 of Annex A.

## **7.5 Screw**

7.5.1 Self-tapping screw type A made of aluminum alloy 6 062, according to ASTM [B209](#), hardness T.6 or duralumin 2 023, diameter of 1/8", length of 1/2", slotted hexagon head.

7.5.2 Self-tapping screw type A made of stainless steel type 304 or 316 or galvanized carbon steel or coated with zinc-nickel (according to ASTM [B841](#), Class I, type B/E, Gr. 5 to 8, with tension and hydrogen relief, according to ASTM [B849](#) and [B850](#)), diameter of 1/8", length of 1/2", slotted pan head.

7.5.3 Self-tapping screw type A made of stainless steel type 304 or 316, or galvanized carbon steel or coated with zinc-nickel (according to ASTM [B841](#), Class I, type B/E, Gr. 5 to 8 tension and hydrogen relief, according to ASTM [B849](#) and [B850](#)), diameter of 3/16", length of 3/4", slotted hexagon head, with washer.

## **7.6 Washer**

7.6.1 Plain washer made of stainless steel type 304 or 316 or galvanized carbon steel or coated with zinc-nickel (according to ASTM [B841](#), Class I, type B/E, Gr. 5 to 8 with tension and hydrogen relief, according to ASTM [B849](#) and [B850](#)), for 3/16" screw, outside diameter of 7/8", inside diameter of 7/32" and thickness of 1/16".

7.6.2 Plain washer made of rubber (neoprene or similar) for 3/16" screw, outside diameter of 7/8", inside diameter of 7/32" and thickness of 1/8".

7.6.3 Plain washer made of stainless steel type 304 or 316 or galvanized carbon steel or coated with zinc-nickel (according to ASTM [B841](#), Class I, type B/E, Gr. 5 to 8 with tension and hydrogen relief, according to ASTM [B849](#) and [B850](#)), for 1/8" screw, outside diameter of 5/8", inside diameter of 5/32" and thickness of 3/64".

## **7.7 Clip**

7.7.1 "S" clip of aluminum alloy 3 003 or 5 005, according to ASTM [B209](#), hardness H-14 to H-19, thickness of 0,50 mm, according to Figure A.5 of Annex A.

7.7.2 "J" clip of aluminum alloy 3 003 or 5 005, according to ASTM [B209](#), hardness H-14 to H-19, thickness of 0,50 mm, according to Figure A.5 of Annex A.

7.7.3 Carbon steel pressure clip SAE 1 010, plain type, thickness of 1 mm, square in the dimensions of 38 mm x 38 mm or circular in diameter of 38 mm, for pins with diameter of 3/16", galvanized or coated with zinc-nickel (according to ASTM [B841](#), Class I, type B/E, Gr. 5 to 8 with tension and hydrogen relief, according to ASTM [B849](#) and [B850](#)), according to Figure A.4 of Annex A.

## **7.8 Rivet**

Open end or hermetic pop rivet made of aluminum, with steel mandrels with dished tab, nominal diameter from 3,2 mm or 4,0 mm, type "pop".

## **7.9 Support**

7.9.1 Steel support according to ASTM [A36/A36M](#), to support the rigid insulating on vertical piping or on piping with a slope greater than 45°, according to Figure A.6 of Annex A.

7.9.2 Support of treated wood (preservative treatment in autoclave), polyurethane or polyisocyanurate of minimum density of 150 kg/m<sup>3</sup> or engineering plastic, to support low temperature piping and equipment.

## **7.10 Quick Release Device**

7.10.1 Quick release device of galvanized carbon steel SAE 1 010, according to ASTM [A109/A109M](#), zinc layer thickness of 12 µm, finish Type II, according to ASTM [B633](#), according to Figure A.7 of Annex A. **[Recommended Practice]**

7.10.2 Quick release device of aluminum alloy 3 003 or 5 005, according to ASTM [B209](#), hardness H-14 to H-19, according to Figure A.8 of Annex A. **[Recommended Practice]**

7.10.3 Quick release device of stainless steel type 304 or 316, according to ASTM [A167](#) and [A 480/A480M](#) according to Figure A.9 of Annex A. **[Recommended Practice]**

## **7.11 Anchor Pin**

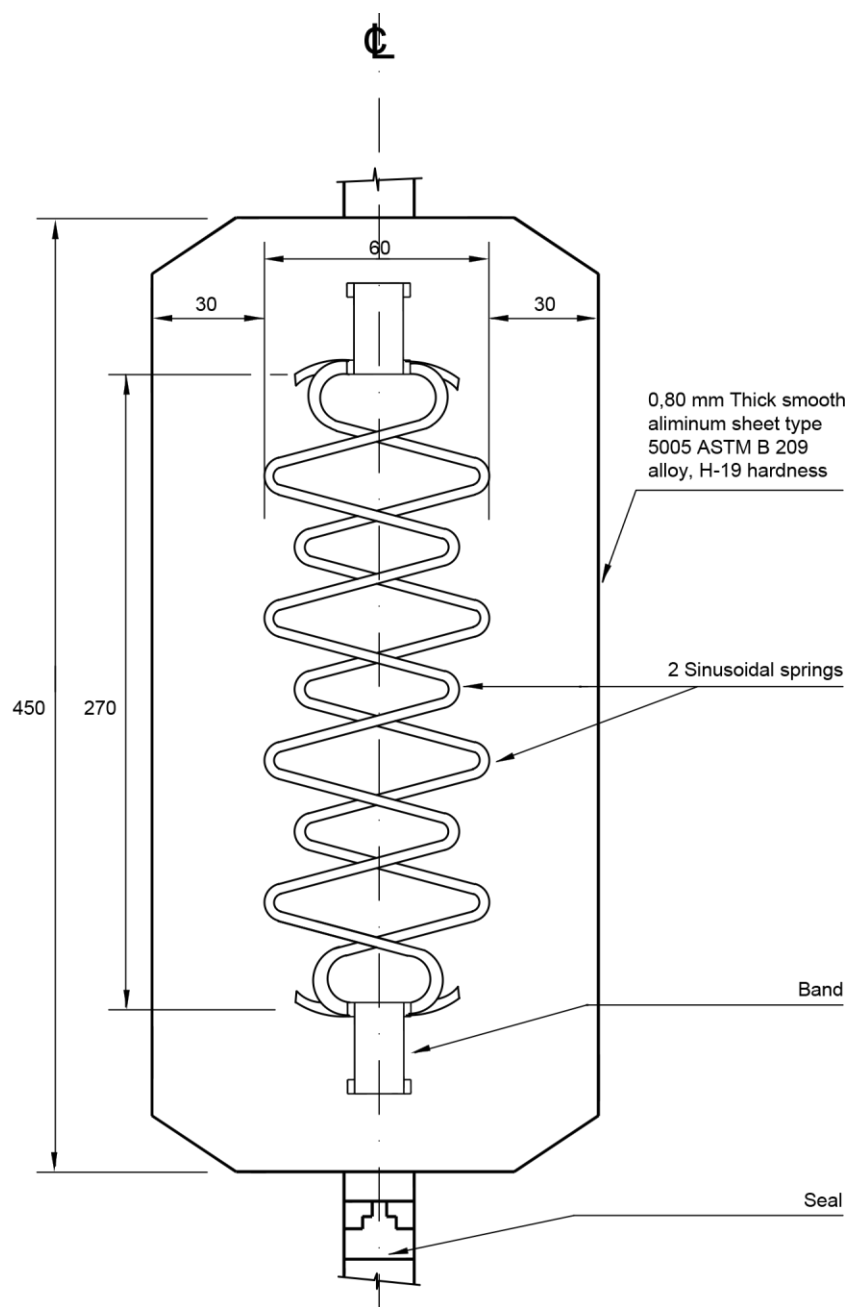
Anchor pin of carbon steel SAE 1 010, plain, diameter of 3/16", according to Figure A.11 of Annex A.

## **7.12 Inspections Boxes and Windows**

7.12.1 Inspection boxes for periodical thickness measurements of equipment and piping, manufactured by aluminum plate, according to Figure A.10.1 of Annex A.

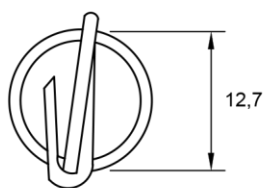
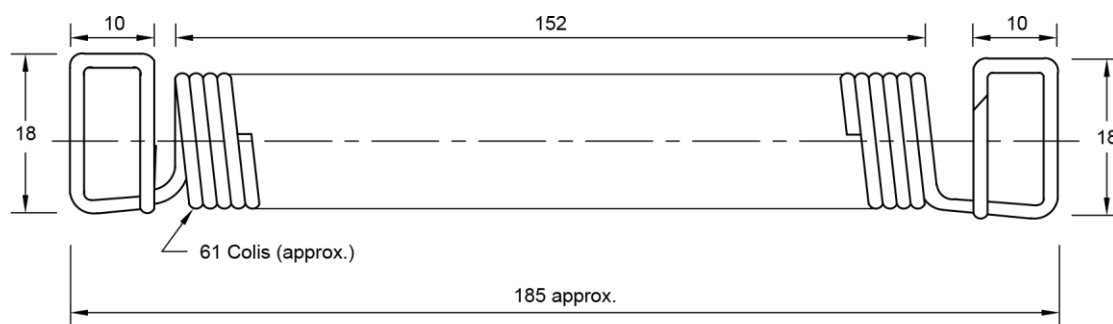
7.12.2 Windows for periodic thickness measurement in equipment and pipes, composed of aluminum flanged rim, silicone plug and galvanized carbon steel cable, according to model Figure A.10.2 of Annex A. The inspection access must have a minimum opening of 100 mm in diameter and the silicone plug must be suitable for continuous use at 250 ° C and withstand exposure prolonged in the sun (resistant to ultraviolet rays).

**Annex A – Figures**



NOTE Dimensions in millimeters.

**Figure A.1 - Sinusoidal Spring**

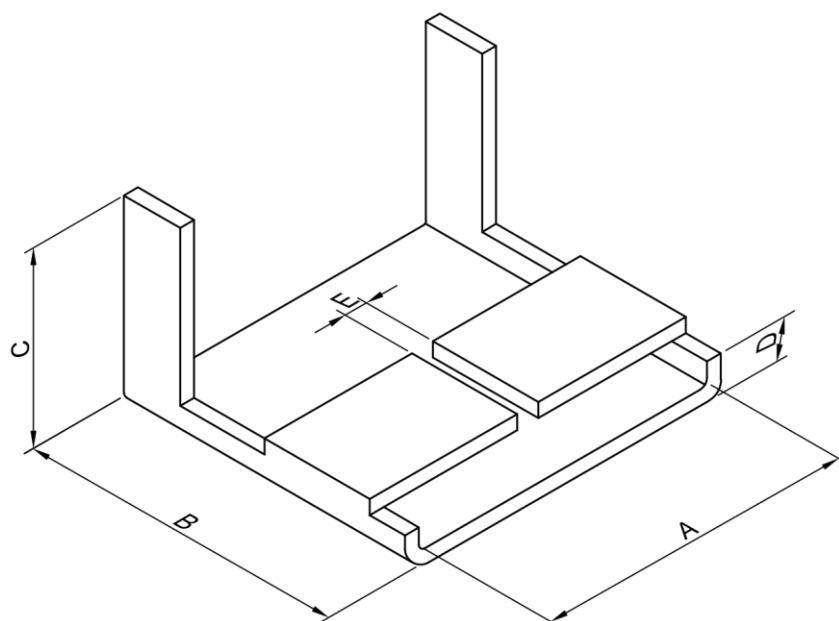


Side view

NOTE Dimensions in millimeters.

**Figure A.2 - Helical Spring**

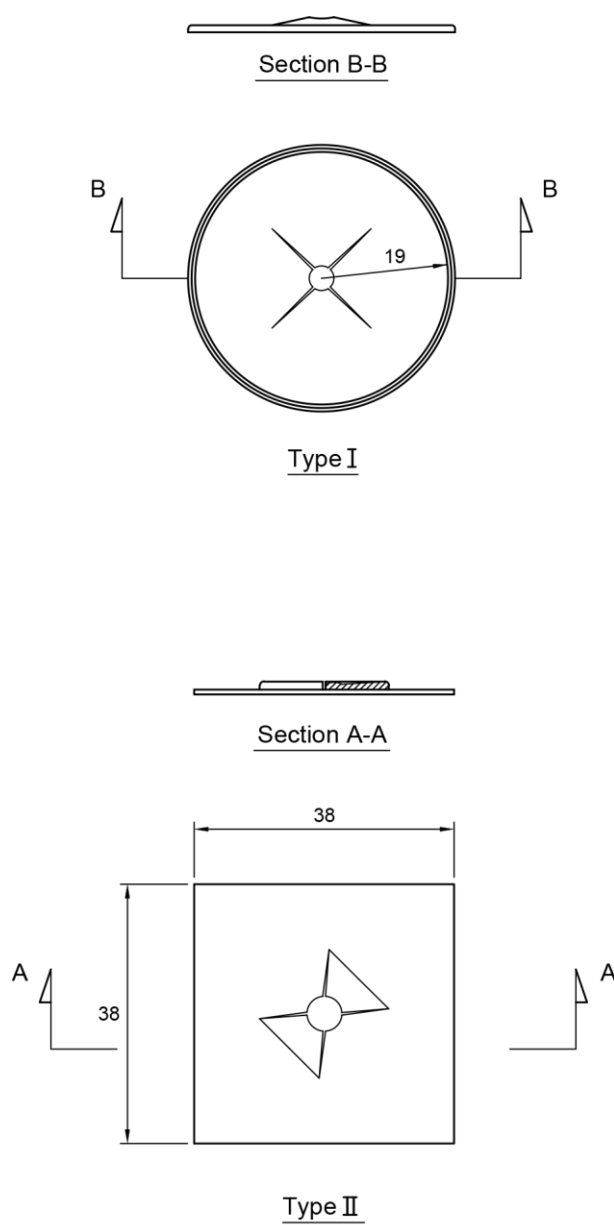




Seal	A	B	C	D	E
1/2"	13	22	10	4	1
3/4"	21	22	14	4	1

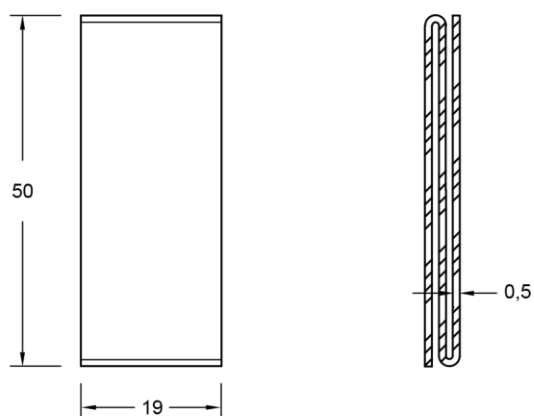
NOTE Dimensions in millimeters, except where otherwise indicated.

**Figure A.3 - Seal**

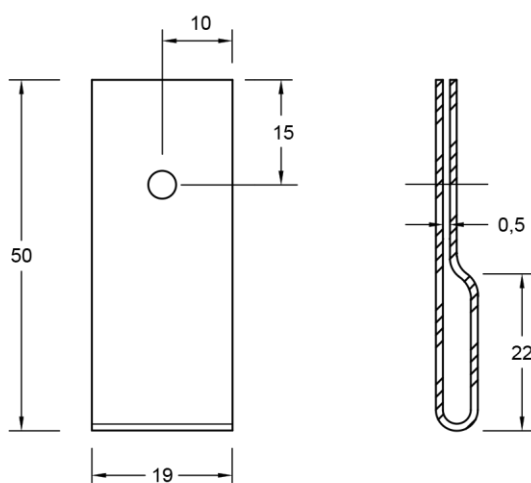


NOTE Dimensions in millimeters.

**Figure A.4 - Pressure Clip**



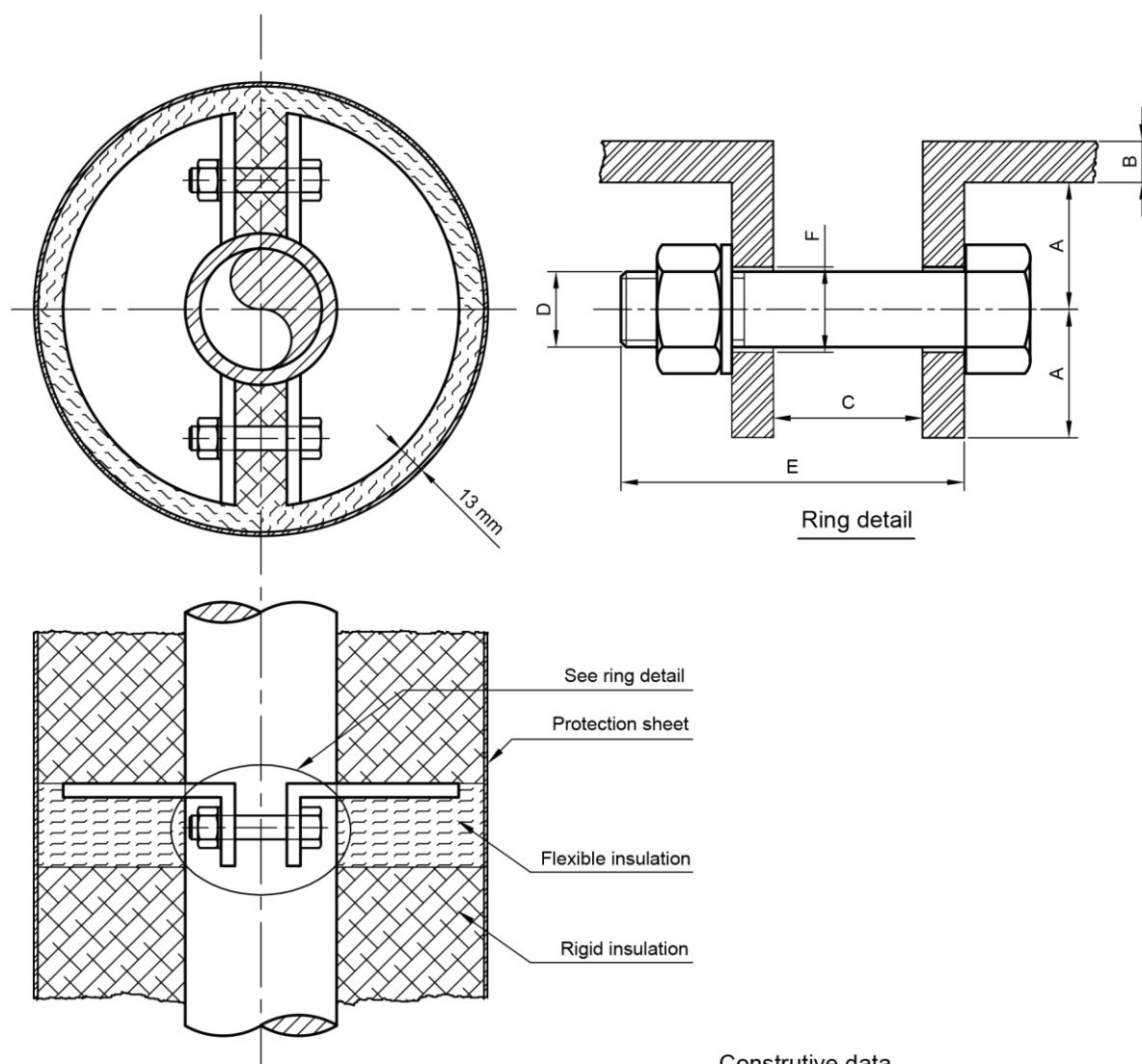
a) "S" Clip



b) "J" Clip

NOTE Dimensions in millimeters.

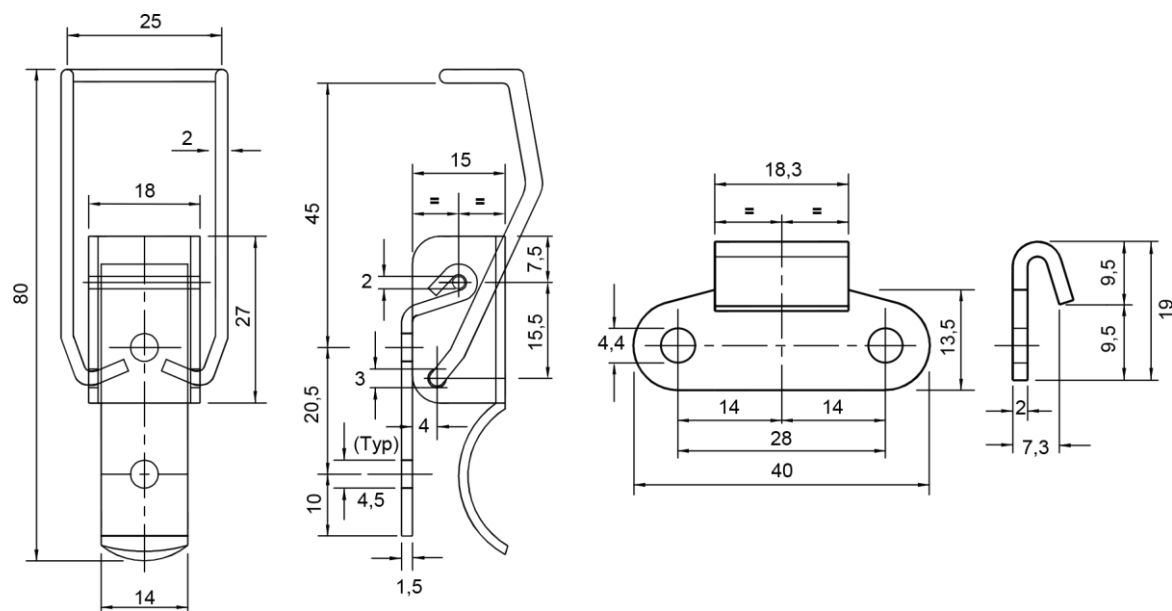
**Figure A.5 - Clip**



Construtive data

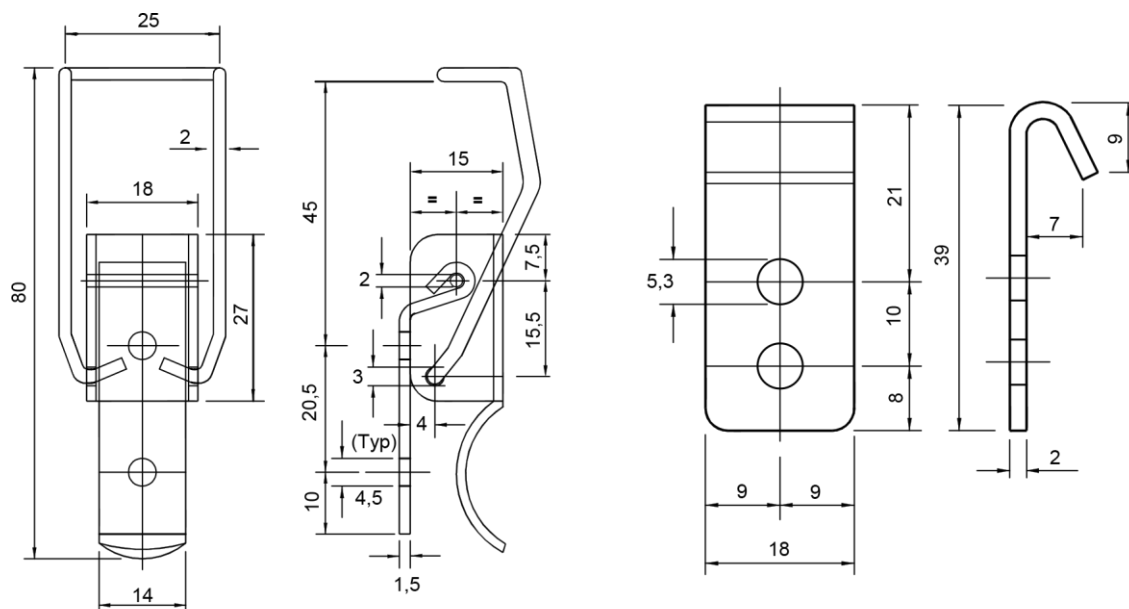
Spacing between supports		Pipe nominal diameter Inches	Inter. ring Diameter mm	A mm	B mm	C mm	D mm	E mm	F mm
Up to 100		1/2	22	12,7	3,2	3,2	6,4	25,4	9,5
101 to 200		3/4	27	12,7	3,2	3,2	6,4	25,4	9,5
201 to 260		1	33	12,7	3,2	3,2	6,4	25,4	9,5
261 to 370		1 1/2	49	12,7	3,2	3,2	6,4	25,4	9,5
371 to 650		2	60	19	4,7	4,7	9,5	31,7	12,7
Above 650		3	89	19	4,7	4,7	9,5	31,7	12,7
		4	114	19	4,7	4,7	9,5	31,7	12,7
		6	168	19	4,7	4,7	9,5	31,7	12,7
		8	219	25,4	6,4	6,4	12,7	38,1	15,8
		10	273	25,4	6,4	6,4	12,7	38,1	15,8
		12	323	25,4	6,4	6,4	12,7	38,1	15,8
		14	355	25,4	6,4	6,4	12,7	38,1	15,8
		16	408	25,4	6,4	6,4	12,7	38,1	15,8
		18	457	25,4	6,4	6,4	12,7	38,1	15,8
		20	508	25,4	6,4	6,4	12,7	38,1	15,8
		22	558	25,4	6,4	6,4	12,7	38,1	15,8

**Figure A.6 - Supports for Rigid Insulation of Vertical Piping or Piping with a Slope Greater than 45**



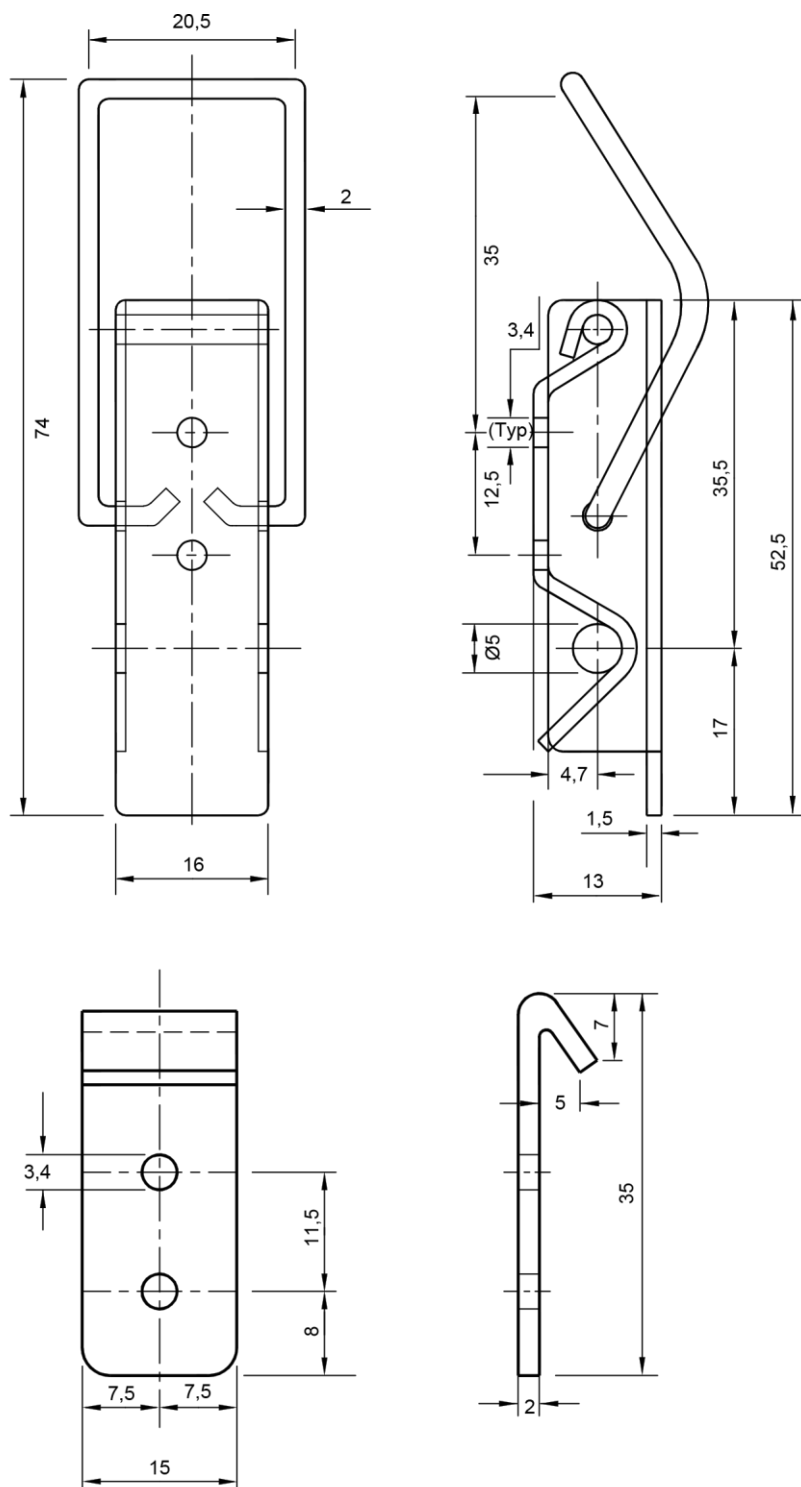
NOTE Dimensions in millimeters.

**Figure A.7 - Galvanized Carbon Steel Quick Release Device**



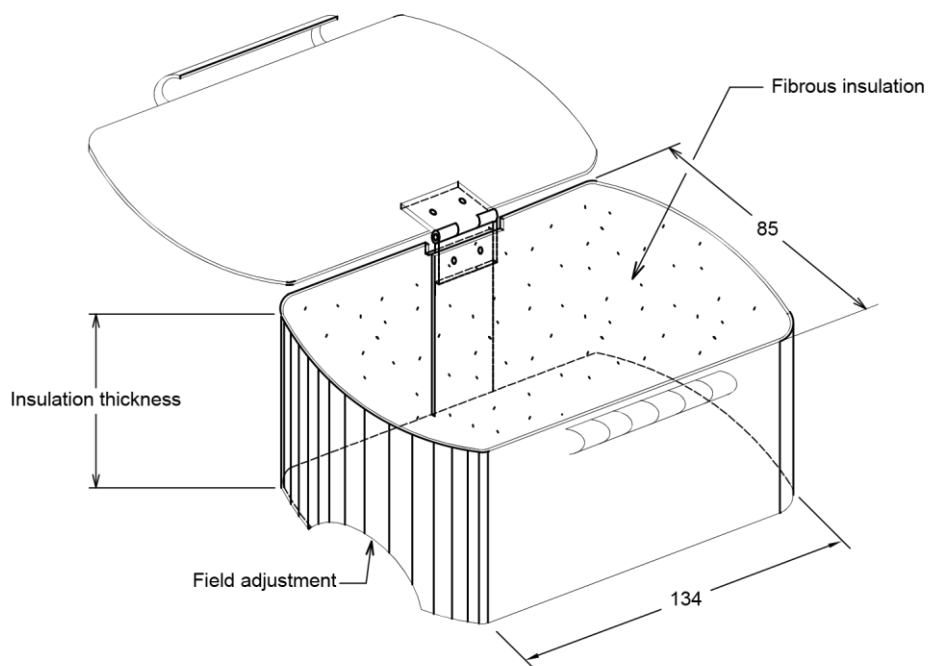
NOTE Dimensions in millimeters.

**Figure A.8 – Aluminum Quick Release Device**

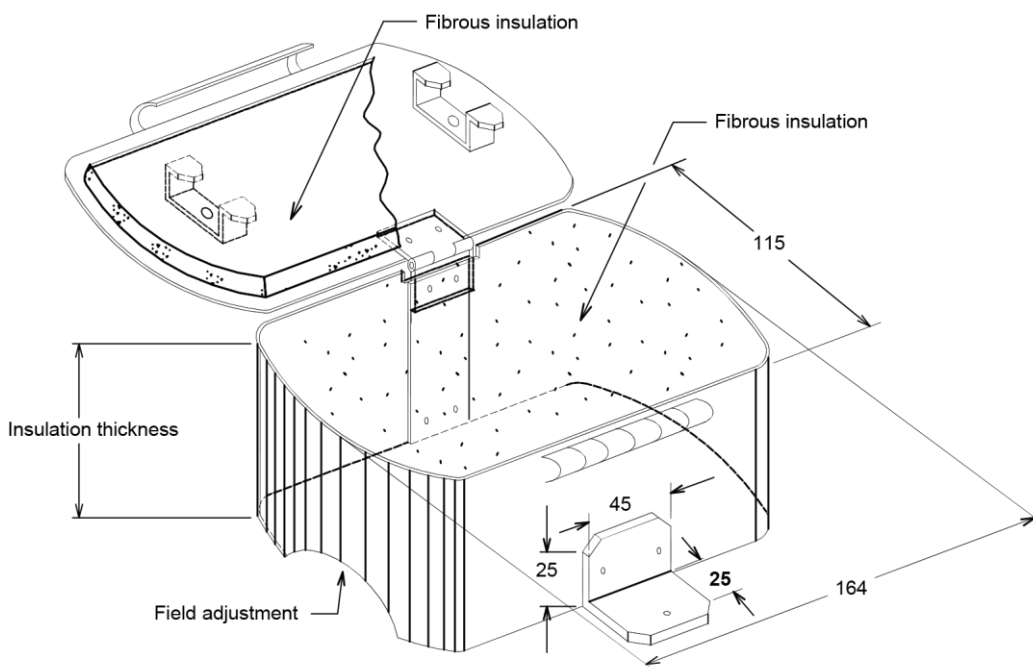


NOTE Dimensions in millimeters.

**Figure A.9 - Stainless Steel Quick Release Device**



Box for measuring thickness of pipe up to 2 1/2 in nominal diameter



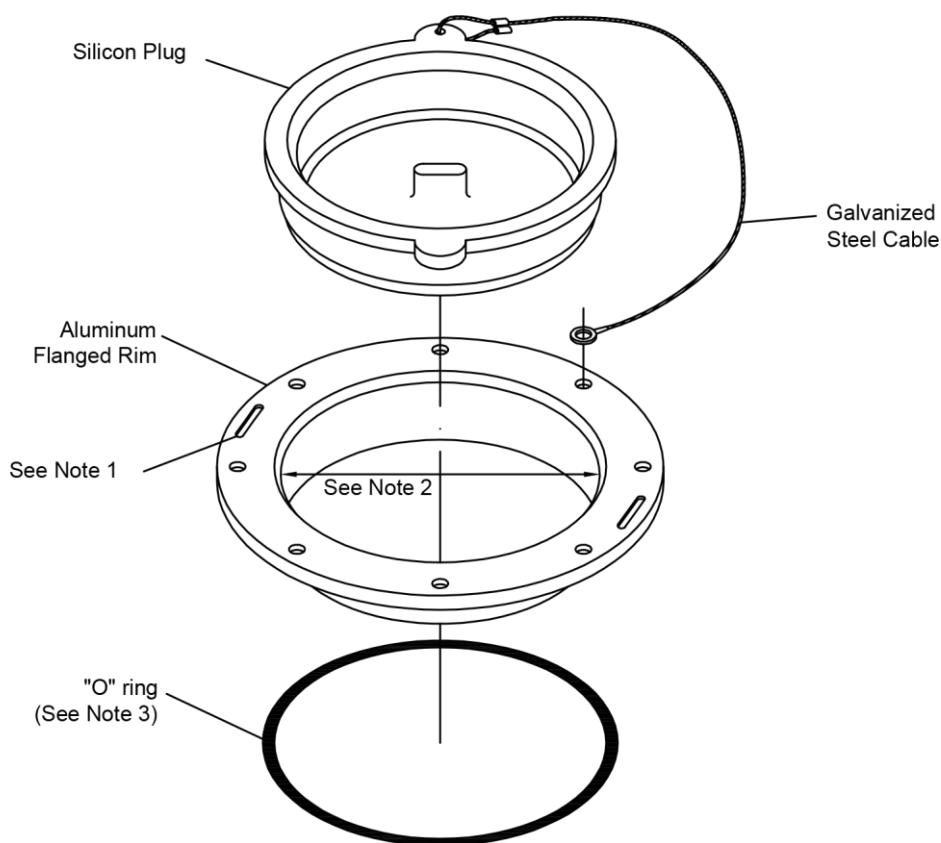
Box for measuring thickness of pipe up to 3" in nominal diameter of larger

NOTE 1 1 mm thick aluminum sheet.

NOTE 2 Dimensions in millimeters, except where otherwise indicated.

**Figure A.10.1 – Inspection Boxes**

**Figure A.10 – Periodical Measurement Inspection Port**



Note 1 Oblong hole for fixing the inspection window using a 12,7 mm strap.

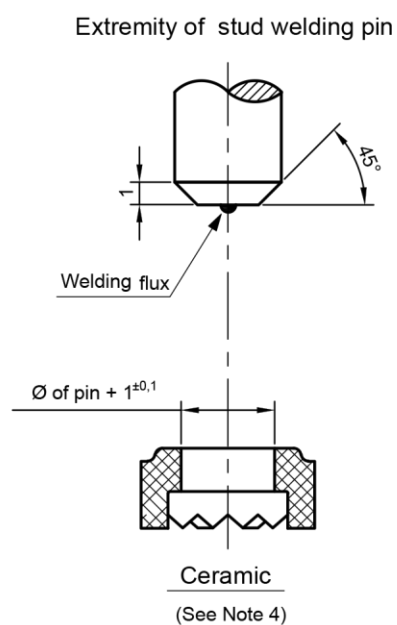
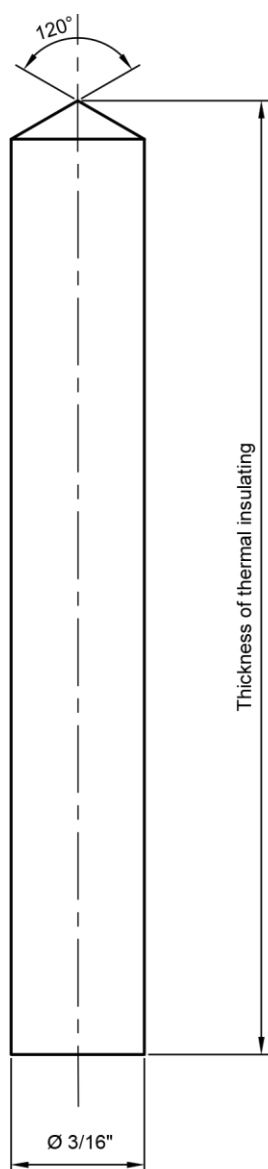
Note 2 Minimum opening of 100 mm.

Note 3 Optionally, it can be supplied with an "o" ring for sealing.

**Figure A.10.2 – Inspections Windows**

**Figure A.10 – Periodical Measurement Inspection Port**





NOTE 1 Dimensions in millimeters, except where otherwise indicated.

NOTE 2 Anchor pin of stainless steel SAE 1 010.

NOTE 3 General tolerance:  $\pm 5 \%$ , except where otherwise indicated.

NOTE 4 The anchor pin, when welded by stud welding, shall be supplied with the tolerance.

Figure A.11 - Anchor Pin

[illegible]