

## Ceramic Fiber for Fired Heater Internal Linings

### 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.

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Comissão de Normalização  
Técnica

## SC - 09

Thermal Insulation and  
Refractories

### Introduction

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## Foreword

This Standard is the English version (issued in 06/2018) of PETROBRAS [N-1890](#) REV. D 11/2016. 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 establishes the conditions required for design, materials and installation of ceramic fiber internal linings in fired heaters.

1.2 This Standard applies to projects starting from its issue date as well as to existing facilities/equipment when maintenance or remodeling work is done.

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-9](#) - Treatment of Steel Surfaces by Abrasive Blasting and Water Jetting;

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

PETROBRAS [N-1617](#) - Aplicação de Concreto Refratário;

ABNT [NBR 9688](#) - Isolantes Térmicos com Mantas de Fibra Cerâmica;

ABNT [NBR 9909](#) - Painéis Termoisolantes à Base de Fibra Cerâmica;

ABNT [NBR 15239](#) - Tratamento de Superfícies de Aço com Ferramentas Manuais e Mecânicas;

API [STD 560](#) - Fired Heaters for General Refinery Services;

ASME [BPVC Section IX](#) - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers and Welding and Brazing Operators - Welding and Brazing Qualifications;

ASTM [C 177](#) - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

ASTM [C 892-18](#) - Standard Specification for High-Temperature Fiber Blanket Thermal Insulation.

## 3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

### 3.1

#### adhesive

neutral sodium silicate-based material intended for auxiliary adhesion of the ceramic fiber to the aluminum or stainless steel foil of the vapour barrier and to the equipment casing

**3.2****vapour barrier**

lining system used to minimize corrosion attack on equipment casing. It comprises the application of an aluminum or stainless steel foil as a barrier against acid gases

**3.3****adhesive cement**

air setting refractory cement used for bonding ceramic fiber modules to refractory linings

**3.4****coating**

refractory material used as a coating element for ceramic fiber modules aiming to increase resistance to erosion and abrasion caused by the flow of combustion gases as well as by suspended solid particles from the combustion process, besides reducing attack by sulfur, vanadium and sodium compounds in the ceramic fiber modules

**3.5****ceramic fiber rope**

product made from ceramic fibers with or without reinforcements used for sealing or insulation in areas with a complex geometry

**3.6****stiffener of ceramic fiber blanket**

inorganic colloidal compound used on wet ceramic fiber blankets or as an agent for surface treatment of dry ceramic fiber blankets to increase their surface resistance

**3.7****ceramic fiber**

high purity material obtained by the fusion of alumina and silica for use at temperatures up to 1 260 °C and alumina, silica and zirconia for use at temperatures up to 1 427 °C

**3.8****blanket**

product obtained by interweaving ceramic fibers through a needling process, comprising a flexible material with uniform thicknesses and densities and free from binders and/or resins

**3.9****blanket with stiffener (wet)**

product made from ceramic fiber blankets with addition of inorganic binders, resulting in a part having a rigid structure when air-dried or when equipment is heated

**3.10****anticorrosive mastic**

material used as anticorrosive lining amid acid vapors, minimizing the effects of corrosion by condensation on the casings

**3.11****pumpable mastic**

mixture of ceramic fibers and binders for high temperatures intended for repairing slots and cracks by pumping.

**3.12** **moldable mastic**

mixture of ceramic fibers and binders for high temperatures used for filling ceramic cones and slots as well as for covering anchoring washers

**3.13** **anchored module**

ceramic fiber block with an integrated attachment system

**3.14** **bonded module**

ceramic fiber block bonded with adhesive cement, normally applied on refractory linings

**3.15** **frame for observation door**

light vacuum-molded ceramic fiber part which is inert to thermal shock already provided in the specified format for easy and quick application

**3.16** **board**

product with characteristics which are similar to the blanket's and provided in parts (board)

**3.17** **ceramic fiber paper**

easily cuttable and adaptable fine and flexible material for regions with complex geometry

**3.18** **special parts**

parts having an irregular geometric shape which is not a market standard, made out of ceramic fiber products

**3.19** **ceramic fiber boards**

rigid product made from vacuum-formed ceramic fibers with the addition of organic and/or inorganic binders

**4 Materials****4.1 Anchoring Devices**

Materials of anchoring devices shall comply with the criteria of Table 12 of API [STD 560](#).

**4.1.1 Auxiliary Anchoring Washer**

Devices used to assist the installation of the blanket's intermediate layers (see Figure A.1.1 of Annex A).

**4.1.2 Ceramic Cone**

Refractory parts used for attaching the layers of ceramic fiber blankets (see Figure A.2 of Annex A).

### 4.1.3 Stud and Anchoring Washer

Devices used for attaching the ceramic blanket in accordance with Figures A.1.2 and A.3 of Annex A.

### 4.1.4 Anchoring of Ceramic Fiber Modules

The type of metal devices used for attaching ceramic fiber modules shall be determined as specified by the designer or manufacturer. The use of a stud with minimum diameter of 3/8" for ceiling and 5/16" for walls is recommended. **[Recommended Practice]**

## 4.2 Ceramic Fiber Materials

### 4.2.1 Board

The required characteristics are those contained in ABNT [NBR 9909](#) with the following restrictions and modifications:

- a) for internal use in fired heaters, class A or B of ABNT [NBR 9688](#) must be specified, depending on the operating temperature;
- b) fibers may be composed of metal oxides of, but not limited to, aluminum ( $\text{Al}_2\text{O}_3$ ), silicon ( $\text{SiO}_2$ ), calcium ( $\text{CaO}$ ), magnesium ( $\text{MgO}$ ) and zirconium ( $\text{ZrO}_2$ ).
- c) addition of reinforcement with synthetic fibers is allowed;
- d) for class A, use only the densities of 64 kg/m<sup>3</sup>, 96 kg/m<sup>3</sup>, 128 kg/m<sup>3</sup>, 160 kg/m<sup>3</sup> and 192 kg/m<sup>3</sup>;
- e) for class B, use only the densities of 96 kg/m<sup>3</sup>, 128 kg/m<sup>3</sup>, 160 kg/m<sup>3</sup> and 192 kg/m<sup>3</sup>;
- f) for design and qualification purposes, the thermal conductivity shall comply with the values in Table 2 of ASTM [C 892](#) as measured by ASTM [C 177](#). Consider grade 4 for 64 kg/m<sup>3</sup>, grade 6 for 96 kg/m<sup>3</sup>, grade 8 for 128 kg/m<sup>3</sup>, grade 10 for 160 kg/m<sup>3</sup> and grade 12 for 192 kg/m<sup>3</sup>.

### 4.2.2 Blanket

The required characteristics are those contained in ABNT [NBR 9688](#) with the following restrictions and modifications:

- a) for internal use in fired heaters, class A or B of ABNT [NBR 9688](#) must be specified, depending on the operating temperature;
- b) fibers may be composed of metal oxides of, but not limited to, aluminum ( $\text{Al}_2\text{O}_3$ ), silicon ( $\text{SiO}_2$ ), calcium ( $\text{CaO}$ ), magnesium ( $\text{MgO}$ ) and zirconium ( $\text{ZrO}_2$ ).
- c) addition of reinforcement with synthetic fibers is allowed;
- d) for class A, use only the densities of 64 kg/m<sup>3</sup>, 96 kg/m<sup>3</sup>, 128 kg/m<sup>3</sup>, 160 kg/m<sup>3</sup> and 192 kg/m<sup>3</sup>;
- e) for class B, use only the densities of 96 kg/m<sup>3</sup>, 128 kg/m<sup>3</sup>, 160 kg/m<sup>3</sup> and 192 kg/m<sup>3</sup>;
- f) for design and qualification purposes, the thermal conductivity shall comply with the values in Table 2 of ASTM [C 892](#) as measured by ASTM [C 177](#). Consider grade 4 for 64 kg/m<sup>3</sup>, grade 6 for 96 kg/m<sup>3</sup>, grade 8 for 128 kg/m<sup>3</sup>, grade 10 for 160 kg/m<sup>3</sup> and grade 12 for 192 kg/m<sup>3</sup>.

### 4.2.3 Moist Blanket

Required characteristics:

- a) minimum density: 300 kg/m<sup>3</sup> (after binder addition);
- b) other characteristics as in 4.2.2 (before binder addition).



#### **4.2.4 Anchored Module**

Required characteristics:

- a) minimum density: 128 kg/m<sup>3</sup>;
- b) other characteristics as in 4.2.2.

#### **4.2.5 Cemented Module**

Required characteristics:

- a) minimum density: 128 kg/m<sup>3</sup>;
- b) maximum thickness shall be: 102 mm (4");
- c) other characteristics as in 4.2.2.

#### **4.2.6 Boards and Frame for Observation Door**

Required characteristics:

- a) vacuum-molded;
- b) limit use temperature: minimum 1 260 °C or 1 427 °C, as specified in the design.

#### **4.2.7 Moldable/Pumpable Mastic**

Required characteristics:

- a) wet density: 900 kg/m<sup>3</sup> to 1 200 kg/m<sup>3</sup>;
- b) limit use temperature: minimum 1 260 °C or 1 427 °C, as specified in the design.

#### **4.2.8 Paper**

Required characteristics:

- a) density: 160 kg/m<sup>3</sup> to 250 kg/m<sup>3</sup>;
- b) minimum tensile strength after burning: 69 kPa;
- c) limit use temperature: minimum 1 260 °C or 1 427 °C, as specified in the design.

### **4.3 Complementary Materials**

#### **4.3.1 Stiffener of Ceramic Fiber Blanket**

Required characteristics:

- a) minimum density: 1 000 kg/m<sup>3</sup>;
- b) limit use temperature: minimum 1 260 °C;
- c) solid content (maximum): 30 % of SiO<sub>2</sub>.

#### **4.3.2 Adhesive Cement for Ceramic Fiber Modules**

Required characteristics:

- a) basic constitution:
  - Al<sub>2</sub>O<sub>3</sub>: 40 % to 65 %;
  - SiO<sub>2</sub>: 30 % to 45 %;

- b) limit use temperature: minimum 1 350 °C.

#### **4.3.3 Coating for Ceramic Fiber Modules**

Required characteristics:

- a) basic constitution:  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ , may contain  $\text{CrO}_2$  and  $\text{SiC}$ ;  
b) limit use temperature: minimum 1 520 °C.

#### **4.3.4 Aluminum Film for Vapour Barrier**

It shall be 0.1 mm to 0.2 mm thick, and may be annealed.

#### **4.3.5 Stainless Steel Film for Vapour Barrier**

It shall be austenitic and 0.05 mm-thick.

#### **4.3.6 Anticorrosive Mastic**

Required characteristics:

- a) density: 0.9 g/cm<sup>3</sup> to 1.6 g/cm<sup>3</sup>;  
b) limit use temperature: minimum 160 °C;  
c) weight loss at 25 °C: maximum 5 %;  
d) non-flammable (when dry).

#### **4.3.7 Adhesive**

Required characteristics:

- a) density: 1 420 kg/m<sup>3</sup>;  
b) viscosity (at 20 °C): 900 cP;  
c) air setting.

#### **4.3.8 Rope**

Required characteristics:

- a) density: 320 kg/m<sup>3</sup>;  
b) limit use temperature: minimum 1 260 °C;  
c) chemical composition: alumina -47 % and silica -53 %;  
d) diameters: 6 mm to 51 mm.

### **4.4 Receiving Inspection**

4.4.1 A visual and dimensional inspection shall be made upon receipt of the materials for checking compliance with the purchase specifications.

4.4.2 The Quality Certificate issued by the manufacturer shall be analyzed, comparing the values of the parameters with those specified in this Standard.

## 5 Design of Fired Heaters

5.1 The ceramic fiber lining shall be designed in accordance to API [STD 560](#) requirements.

5.2 It is not allowed to install coatings composed only by layers of ceramic fiber in the sections of radiation and convection of furnaces, their use being allowed only in header boxes.

NOTE In the radiant section, it is only allowed to install ceramic fiber blankets in complementary layers to modules (for instance, in a vapour barrier or sacrificial layer).

5.3 Ceramic fiber products shall not be installed in regions which are prone to the direct incidence of flames.

5.4 If necessary, protect the modules surface, applying surface protection (coating).

5.5 If necessary, increase the resistance of high speeds of gases, applying stiffener on the last layer of blankets or use a wet blanket. Coating shall not be applied as surface protection for the ceramic blanket.

5.6 The use of vacuum-formed rigid boards as sacrificial layers on the fiber lining is recommended in high speed-prone areas. **[Recommended Practice]**

5.7 In case the surface to be lined is corrosion-prone because of the condensation of acid gases, a protection with anticorrosive mastic shall be applied on the casing. For fuels with sulfur content of 500 ppm or above, a vapour barrier shall be used as specified on API [STD 560](#) and occasionally, if necessary, surface protection shall also be adopted.

## 6 Installation

### 6.1 General Requirements

6.1.1 When the welding of the anchor in the plating is carried out by conventional processes (Shield Metal Arc Welding – SAME, GTAW etc.) it shall comply with PETROBRAS [N-133](#).

6.1.2 The stud welding process may also be used, provided the procedure is qualified according to code ASME [BPVC Section IX](#).

6.1.3 Plating shall be cleaned for stud welding and coating application with commercial abrasive blasting, according to PETROBRAS [N-9](#), grade Sa 2, or with mechanical tools, according to ABNT [NBR 15239](#), degree St 2.

6.1.4 Before welding, the plating shall be cleaned so as to be free of abrasive residue, dust, oil and mill scale.

6.1.5 Is not allowed to fold ceramic fiber blankets for the propose of forming modules or panels.

## **6.2 Installation of Boards and Blankets**

6.2.1 Specification of each blanket shall meet the temperature limits established for each ceramic fiber class.

6.2.2 The arrangement of layers near to regions with castable refractory shall be in accordance with Figure A.4 of Annex A.

6.2.3 The arrangement of layers near pipe inlets or outlets, or any other interference of parts at high temperatures on the walls of the fired heaters may be according to Figure A.5 of Annex A.

6.2.4 Finishing where it comes into contact with the refractory floor shall be in accordance with Figure A.6 of Annex A.

6.2.5 Arrangement of layers on the corners of the furnace walls shall comply with Figure A.7 of Annex A.

6.2.6 The intermediate layers of ceramic blankets installed on fired heater's roofs shall be attached through auxiliary anchoring washers to facilitate installation (see Figure A.1 of Annex A).

6.2.7 The joints of the internal layers shall not coincide and the joints of the last layer shall be of the lap type (in the direction of gas flow) according to Figure A.8 of Annex A.

6.2.8 Studs shall be attached and aligned with the same orientation, as per Figure A.8 of Annex A.

6.2.9 The tips of the studs sticking out on the last layer of the blanket shall be protected with moldable mastic (see Figure A.9 of Annex A). When ceramic cones are used, fill the internal cone with moldable mastic for stud protection.

## **6.3 Installation of Modules**

### **6.3.1 Anchored Modules - Application Methods**

#### **6.3.1.1 Pre-Located**

In modules with an anchoring stud which is welded separately from the module. Application of an anticorrosive mastic is allowed on the casing.

6.3.1.1.1 If applying anticorrosive mastic, the plating surface should be cleaned with a commercial abrasive blast, in accordance with PETROBRAS [N-9](#), degree Sa 2. If not applying anticorrosive mastic, the points of plating where studs were welded, should be cleaned with mechanical tools, in accordance with ABNT [NBR 15239](#), degree St 2. **[Recommended Practice]**

6.3.1.1.2 Mark casing for welding of studs, according to distribution design of anchoring and the manufacturer's application instructions.

6.3.1.1.3 Weld the studs according to PETROBRAS [N-133](#).

6.3.1.1.4 Apply an anticorrosive protection, if necessary.

6.3.1.1.5 Installation of modules shall be in accordance to the manufacturer's procedure, observing all joints, mainly around inspection openings and burner blocks, compression and layout.

### **6.3.1.2 Direct Application**

6.3.1.2.1 Module fixed together with the anchoring stud. Application of an anticorrosive mastic is not allowed.

6.3.1.2.2 The module fixation shall be done on a single operation, composed by stud welding the anchoring and tightening the module locknut, according to design and manufacturer installation instructions, observing all joints, mainly around inspection openings and burner blocks, including compression and layout.

6.3.1.2.3 The plating surface should be cleaned with a commercial abrasive blast, in accordance with PETROBRAS [N-9](#), degree Sa 2. **[Recommended Practice]**

### **6.3.2 Cemented Modules**

Applied to coatings composed by anchored modules of ceramic fiber, refractory bricks or concrete.

**NOTE** The application of cemented modules is only allowed for maintenance interventions, its use not being permitted to make refractory linings in new equipments.

6.3.2.1 Before the adhesion of the cementable modules, a general cleaning shall be performed to remove loose materials, deposits of sulfur compounds, and other contaminants.

6.3.2.2 Occasional repair work shall be done on the base lining prior to receipt of the module.

6.3.2.3 Wet the surface of the base lining and bond the Cemented Modules using the cement specified by the manufacturer.

**NOTE** The cemented modules shall be superficially perforated (with nail board) prior to application, in order to increase the area of contact and adhesion with the base coating.

## **6.4 Special Parts**

They shall be installed according to anchoring system and installation instructions defined by the manufacturer.

## **7 Installation Inspection**

### **7.1 Surface Preparation**

Visually inspect the surface preparation of the entire area, ensuring compliance with item 6.1.3.

## **7.2 Attachment of Anchoring Devices**

Welding of anchoring devices shall be inspected according to standard PETROBRAS [N-1617](#), except with regards to spacing, distribution and dimensions.

**NOTE** Inspection of fixation of direct application module studs (6.3.1.2) shall be done through a prototype, in order to verify the level of quality of welding and qualification of procedure, before the final application in the equipment.

## **7.3 During Application**

The lining shall be visually inspected, checking:

- a) thickness and consistency of the anti-corrosive mastic;
- b) continuity and sealing of the vapour barrier;
- c) system used for attaching blankets (auxiliary and fixing washers) or modules (duly bolted);
- d) lining thickness: tolerance of -10 mm, +20 mm;
- e) presence of slots;
- f) consistency in coating application;
- g) interface joints between modules (if applicable);
- h) interface joints with inspection windows, burner blocks, tubes and brackets.

# **8 Repair**

## **8.1 Low Thickness**

Reconstitute the ceramic fiber coating thickness through replacement of modules or layers of blankets, according to tolerance of 7.3 d) (to install new coatings). In case of repair of coatings subjected to operating conditions, the criteria of Section 9 are applied.

## **8.2 Missing Washers**

Install a new washer in the studs and lock it.

## **8.3 Slots**

They shall be filled with compressed dry ceramic fiber blankets. It is allowed to use pumpable mastic when it is not possible to fill with compacted blanket.

## **8.4 Inconsistent Coating**

Recompose the coating layer on defective areas or with low thickness.

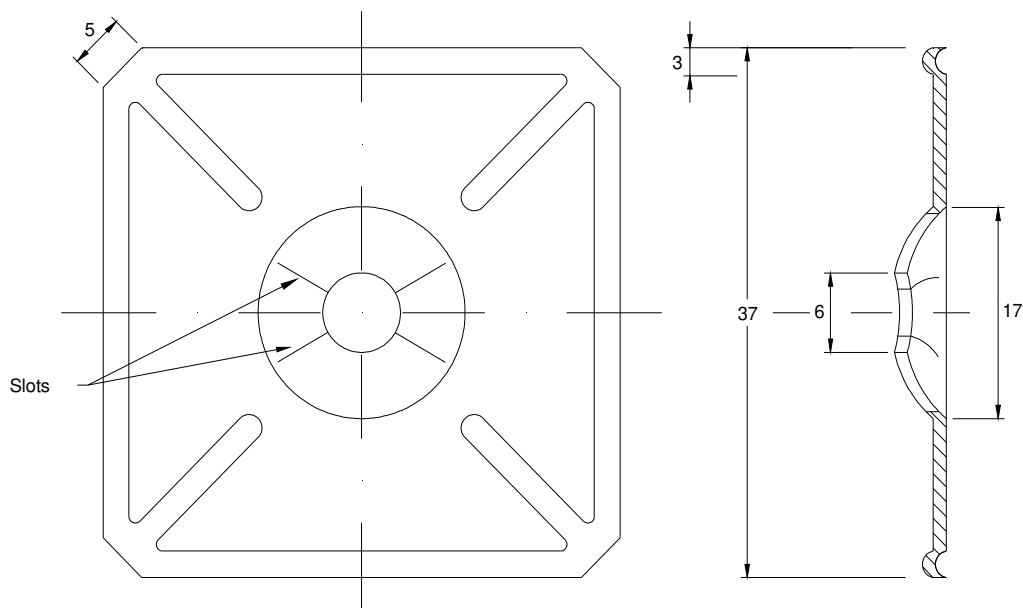
## **8.5 Loose Coating or with Defective Anchoring**

Remove loose area, recompose anchoring provided in the design, and set the coating.

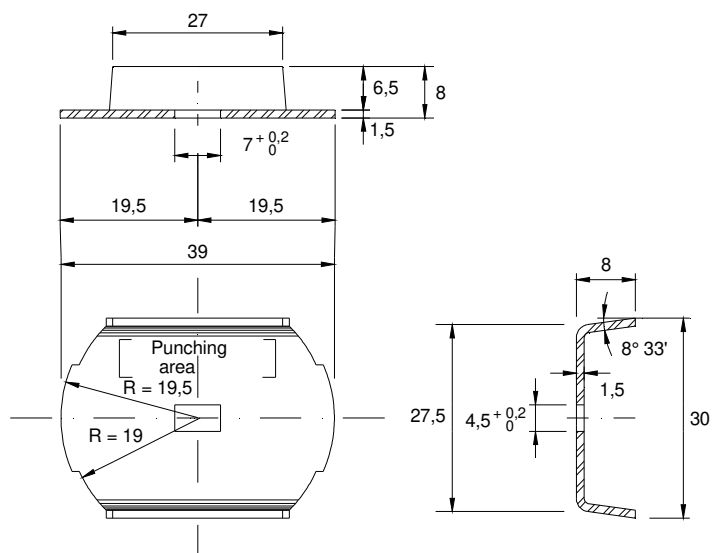
# **9 Inspection and Repair of Ceramic Fiber Linings After Being Exposed to Operating Conditions**

The lining shall be visually inspected, checking on the following conditions:

- a) in coating with of layers of ceramic fiber blankets, in case the lining surface presents areas under chemical attack (loosened fibers) or loss of thickness, all affected layers shall be replaced;
- b) in coatings with cemented or anchored modules, the following criteria shall be applied:
  - loss of thickness  $\leq 1/4$  of the coating: smooth the surface of the module and apply a coating layer;
  - loss of thickness  $> 1/4$  of the coating: replace module;
- c) slots: between modules and vacuum castings are not acceptable and shall be filled with compressed ceramic fiber blanket;
- d) broken or damaged studs shall be removed and replaced;
- e) loose coating or with little anchoring shall be recomposed according to 8.5.

**Annex A - Figures**


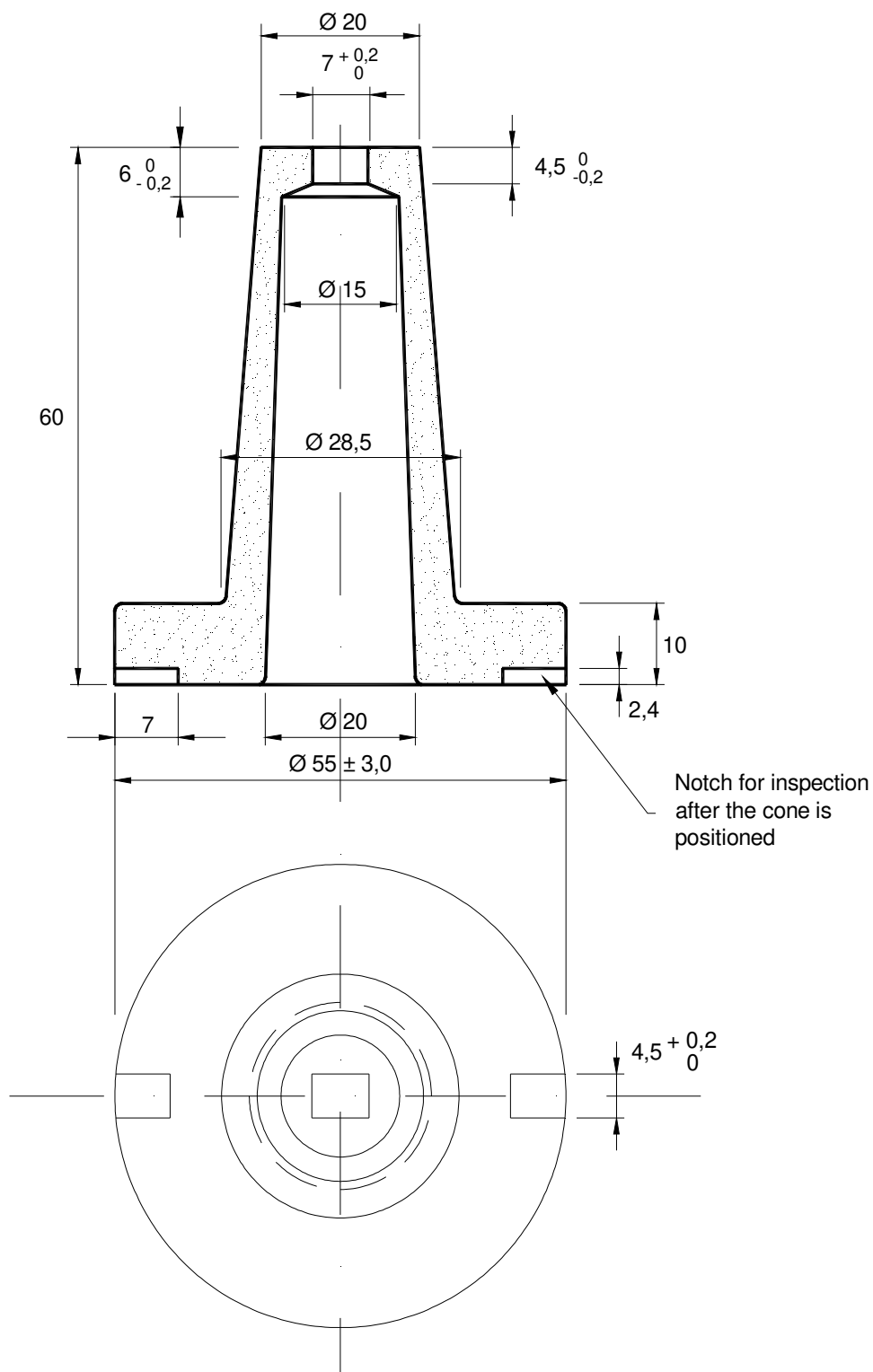
- NOTE 1 USG 20 galvanized plate material.  
NOTE 2 Dimensions registered millimeters.

**Figure A.1.1 - Auxilliary Anchoring Washer**

**Figure A.1.2 - Anchoring Washer**

- NOTE 1 Parts may not have warping or burrs.  
NOTE 2 Overall tolerances:  $\pm 0.5$ , except where otherwise indicated.  
NOTE 3 Dimensions registered in millimeters.  
NOTE 4 Punch on the part the type of stainless steel (see location indicated on the drawing).

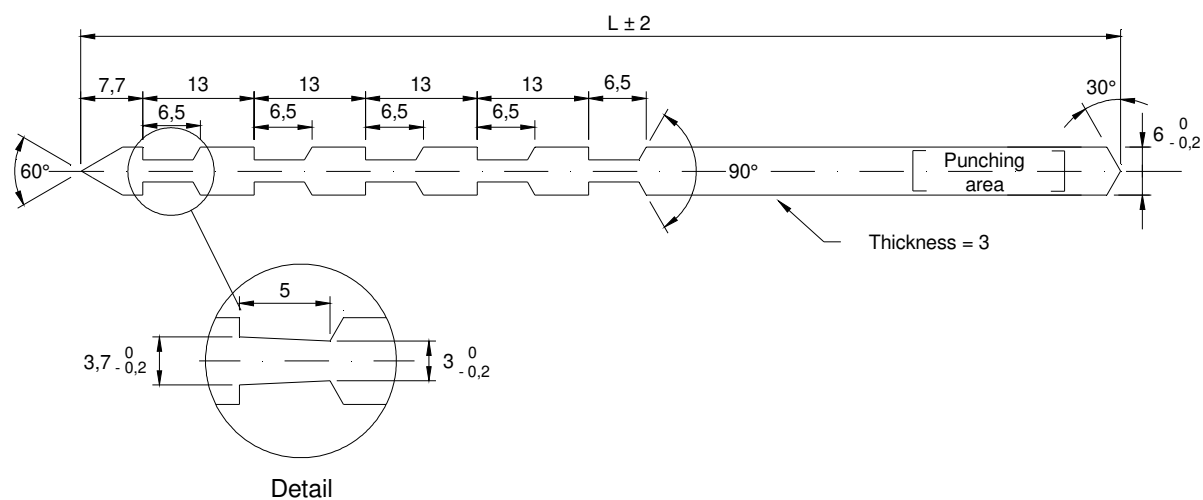
**Figure A.1 - Washer**



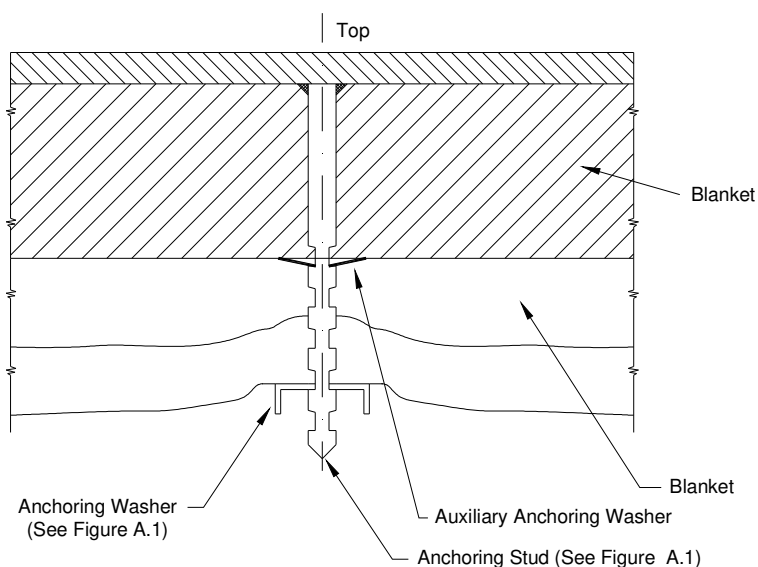


- NOTE 1 Silica alumina refractory material subject to ceramic treatment for working temperatures up to 1 450 °C.  
 NOTE 2 Parts may not have burrs, cracks or deformation.  
 NOTE 3 Overall tolerance:  $\pm 1,5$ , except where otherwise indicated.  
 NOTE 4 Dimensions registered in millimeters, unless otherwise indicated.

**Figure A.2 - Ceramic Cone**



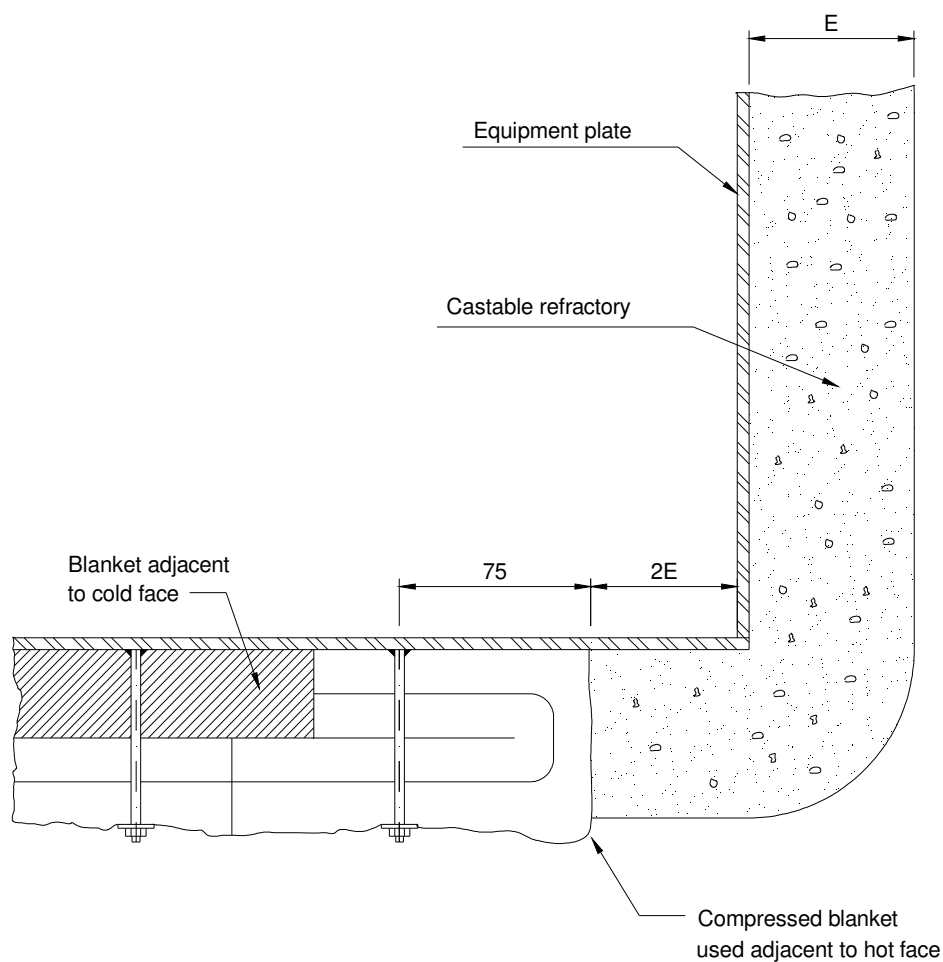
**Figure A.3.1 - Anchoring Stud**



**Figure A.3.2 - General Arrangement: Anchoring Stud, Auxiliary Anchoring Washer and Anchoring Washer**

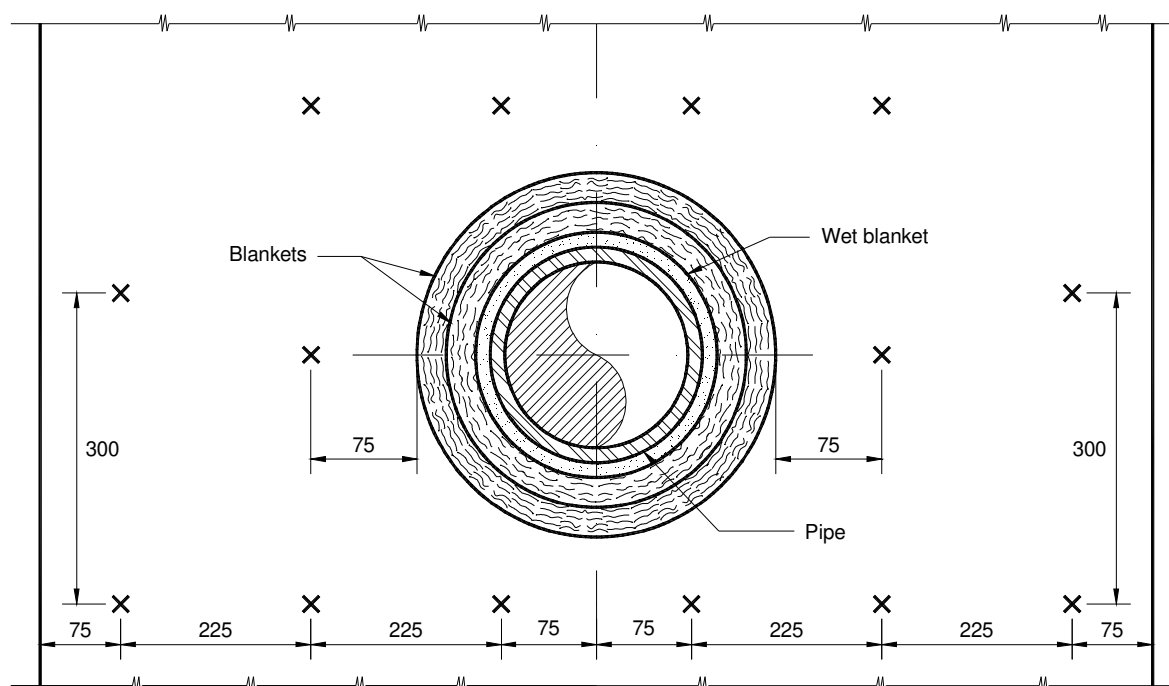
- NOTE 1 Parts may not have warping or burrs.  
 NOTE 2 Overall tolerances:  $\pm 0.5$ , except where otherwise indicated.  
 NOTE 3 Dimensions registered in millimeters, unless otherwise indicated.  
 NOTE 4 Punch on the part the stainless steel grade (see location indicated on the drawing).  
 NOTE 5 "L" is equal to the thickness of the lining when washers are used for attachment and "L" is equal to the thickness of the lining, minus 35 mm when it is attached by a ceramic cone.

**Figure A.3 - Anchoring Stud**



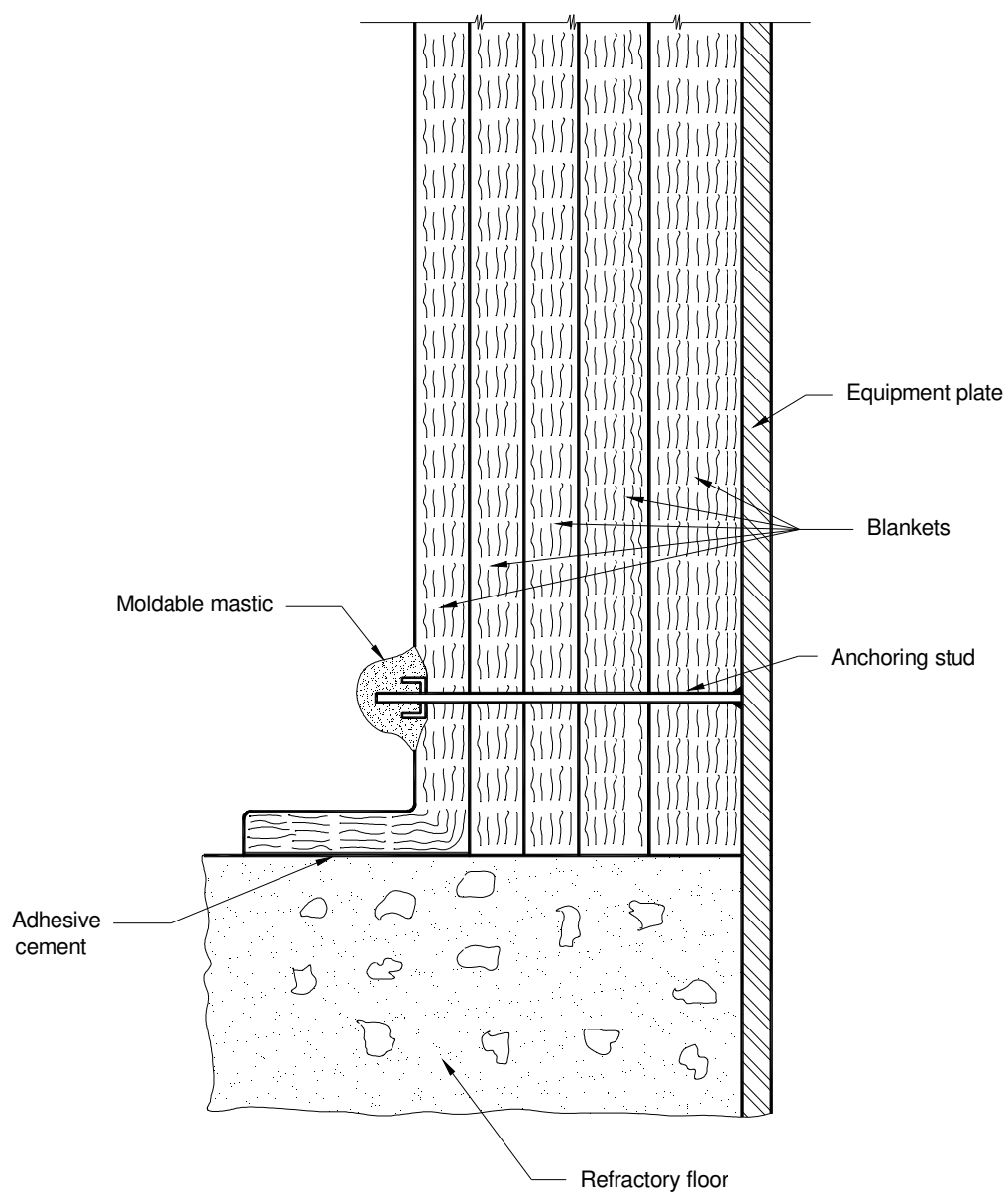
- NOTE 1 E = insulating or castable refractory thickness.  
 NOTE 2 Dimensions registered in millimeters.

**Figure A.4 - Arrangement of Blanket Layers in Regions Covered with Castable Refractory**

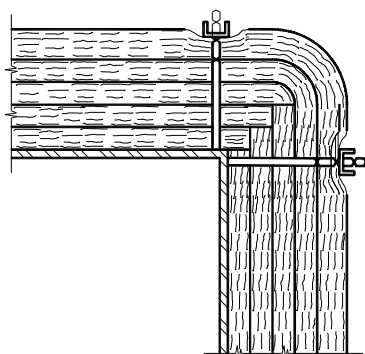


NOTE Dimensions registered in millimeters.

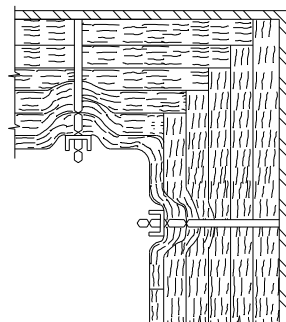
**Figure A.5 - Arrangement of Blankets near Pipe Inlet**



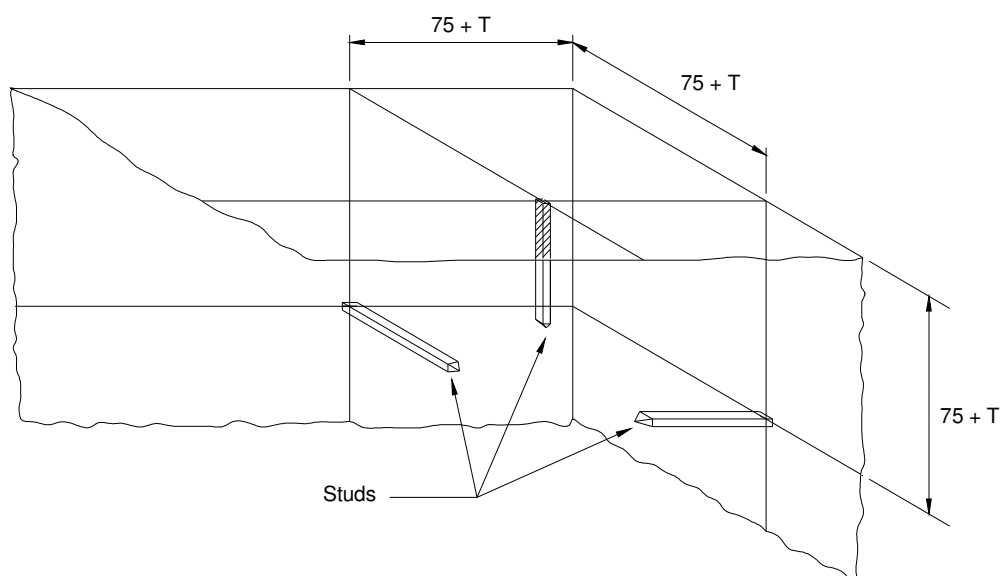
**Figure A.6 - Finishing of Blankets Where it Comes Into Contact with Floors**



Outer corner



Inner corner

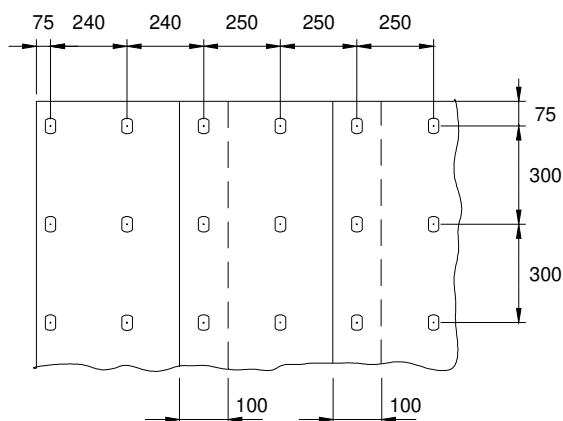
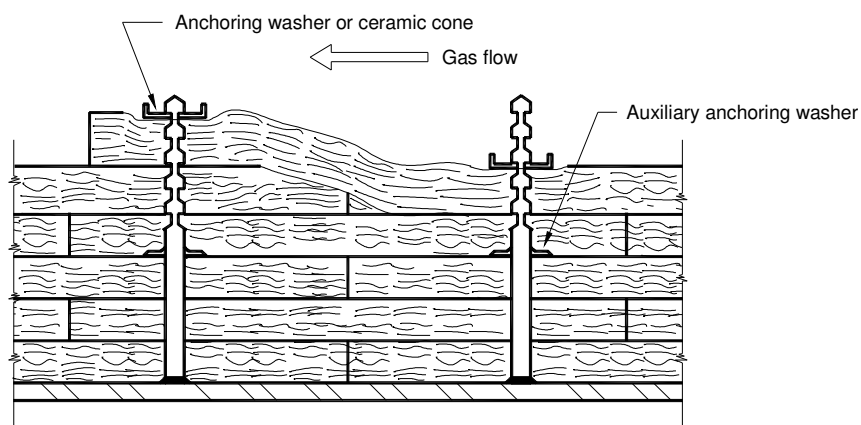


T = Thickness of blankets

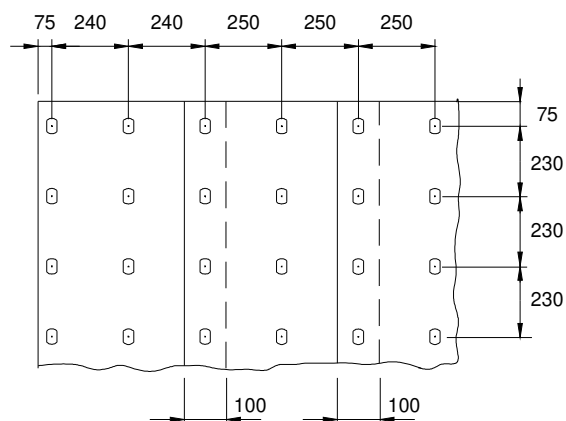
Arrangement of anchoring studs on corners

NOTE Dimension registered in millimeters.

**Figure A.7 - Arrangement of Blanket Layers on Walls Corners**



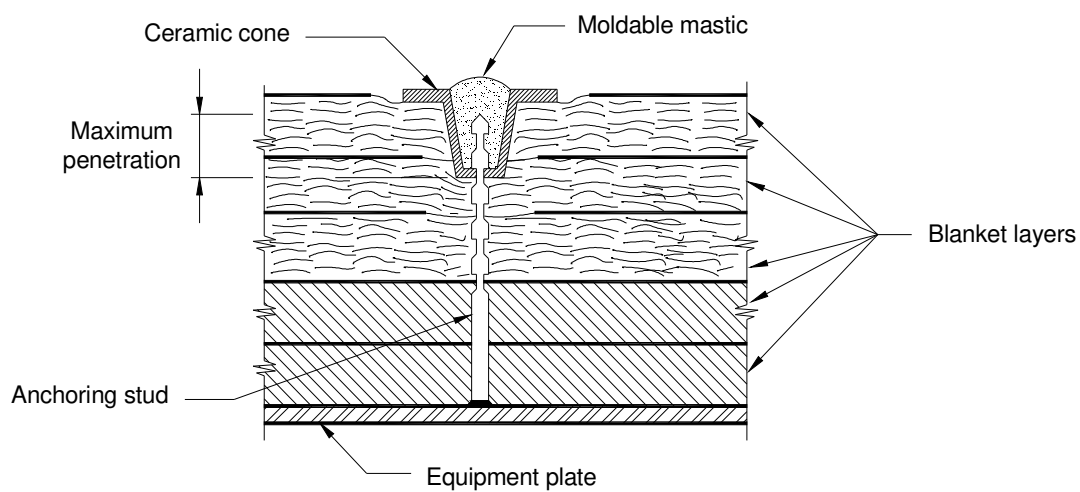
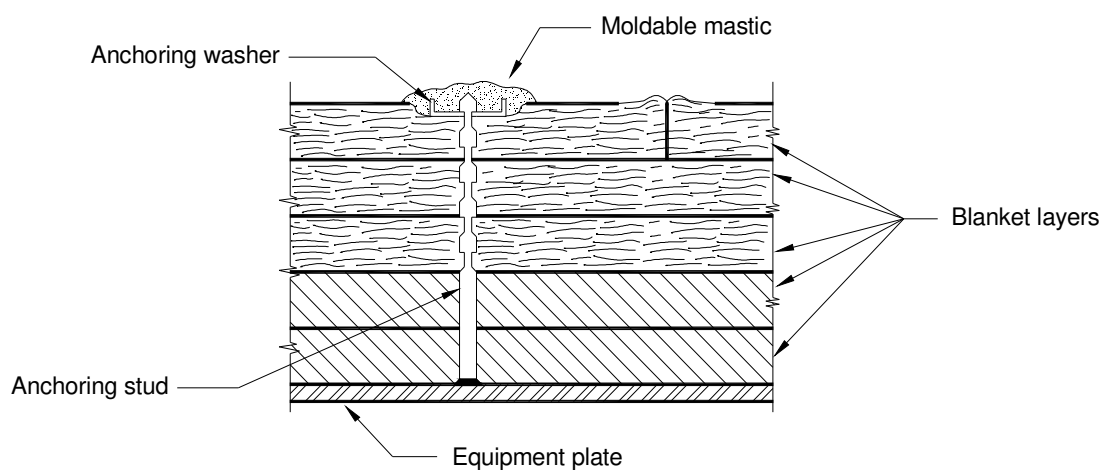
Walls - 13,99 studs / m<sup>2</sup>



Tops - 18,29 studs / m<sup>2</sup>

NOTE Dimension registered in millimeters.

**Figure A.8 - Lap Joint**



**Figure A.9 - Protection of Anchoring Studs**



INDEX OF REVISIONS	
<b>REV. A</b>	
There is no index of revisions.	
<b>REV. B</b>	
Affected Parts	Description of Alteration
3.1 to 3.10	Revised
3.12 to 3.20	Revised
4.1.3 to 4.1.5	Revised
4.2.3 to 4.2.9	Revised
4.3.2 to 4.3.5	Revised
4.3.8	Revised
5	Revised
6.1 to 6.2	Revised
6.3.2.2	Revised
6.3.2.4	Revised
6.3.3.3	Revised
6.4	Revised
7	Revised
Figures A-1 to A-3	Revised
Figure A-4	Included
Figure A-5	Revised
Figures A-9 to A-10	Revised
<b>REV. C</b>	
Affected Parts	Description of Alteration
All	Revised
<b>REV. D</b>	
Affected Parts	Description of Alteration
All	Revised