PETROBRAS

N-1910	REV. H	ENGLISH	09 / 2021

CONTEC
Comissão de Normalização Técnica

SC-09
Thermal Insulation and Refractories

Castable Lining Design

1st Amendment

This is the 1st Amendment to PETROBRAS N-1910 REV. H and it is used to alter the text of the Standard in the part indicated below:

NOTE 1 The new page with the performed amendment is placed in its corresponding position.
NOTE 2 The amended page, indicated the date of the amendment, are placed at the end of this standard, in chronological order, and shall not be used.

CONTENT OF 1st AMENDMENT - 09/2021

- Figure A.16 - Installation of Crown Type Anchors

Alteration of Figure.

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Castable Lining Design

Procedure

This Standard replaces and cancels its previous revision.

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

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

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

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

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

CONTEC
Comissão de Normalização Técnica

SC - 09
Thermal Insulation and 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

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Foreword

This Standard is the English version (issued in 02/2021) of PETROBRAS N-1910 REV. H 10/2019. 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 in the project of refractory castable lining, including selection of refractory material and detailing of their anchorage, used in furnaces, pipes, chimneys, pressure vessels and Fluid Catalytic Cracking (FCCU and RFCCU), including the selection of materials and details of anchorage system.

1.2 This Standard applies to designs started from the date of its edition and also on pre-existing materials, at the time of maintenance or renewal thereof.

1.3 This Standard contains Technical Requirements and Recommended Practices.

2 Normative References

The documents listed below are essential to the application of this document. For dated references, only the mentioned editions shall be applied. For non-dated references,the newest mentioned editions are applied.

PETROBRAS N-133 - Soldagem;

PETROBRAS N-1617 - Aplicação de Concreto Refratário;

PETROBRAS N-1728 - Concreto Refratário;

PETROBRAS N-1890 - Revestimentos Internos de Fibra de Cerâmica;

ABNT NBR 8826 - Materiais Refratários - Terminologia;

ABNT NBR 10662 - Isolantes Térmicos Pré-Moldados de Silicato de Cálcio – Especificação;

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

API STD 560 - Fired Heaters for General Refinery Services.

3 Terms and Definitions

For the purposes of this Standard the terms and definitions of PETROBRAS N-1728 and ABNT NBR 8826 are applied.

4 General Conditions

4.1 All the refractory materials to be used shall be according to PETROBRAS N-1728 and be applied according to PETROBRAS N-1617.

4.2 The thickness of any layer of castable shall at least 50 mm, except for dense castable, applied in hexagonal or articulated meshes, or in independent anchor for linings which thickness is up to 25 mm.

4.3 The welding of anchorage devices shall be performed according to PETROBRAS N-133 and to ASME BPVC Section IX.

4.3.1 The “Stud Welding” process shall be used as an alternative to conventional welding processes for furnaces, regenerator and combustion gas lines of FCCU (except in button curves). **[Recommended Practice]**

4.3.2 The use of the “Stud Welding” process is not permitted in lining applied by the external vibration method or in regions subject to vibration, thermal shock and coke formation.

4.4 When specified, the “V” anchor may be simple or “wavy” according to PETROBRAS N-1728.

4.5 When the first layer is constituted by calcium silicate, ceramic fiber plate or insulating castable, it shall be applied on this layer a tar-based waterproofing painting, PVA (Polyvinyl Acetate)-based, or a plastic polyethylene sheet of 0.10 mm thickness with superposition of 50 mm.

4.6 There shall be expansion joints applied in metallic pieces (nozzles, pipes and supports) that cross refractory walls, which shall meet the following requirements:

a) the expansion joint shall be filled with ceramic fiber PETROBRAS N-1890;
b) the ceramic fiber to fill the expansion joint shall cover the entire metallic surface;
c) the minimum opening of the expansion joints shall be 3 mm;
d) the ceramic fiber surface in contact with castable shall be involved with a 0.05 mm thick aluminum sheet or 0.10 mm polyethylene sheet, with minimum superposition of 50 mm, fixed with adhesive paper tape.

4.7 The designer shall calculate and define the need and location of expansion joints, which shall be according to 4.6.

4.8 In order to allow the free expansion, “V”, “Y” and trident anchors shall receive lining on the edges, which may be of plastic hose or plastic cap so as to obtain lining with minimum thickness of 1 mm and 30 mm length.

4.9 The adoption or not of metallic fibers in the new refractory lining designs is at the discretion of the designer, except for regions subject to vibration and coke formation, where adoption of metallic fibers is compulsory.

4.9.1 Metallic fibers shall not be added in the following cases:

a) on the first layer in double layer linings;
b) in operating temperature above 1 000 °C;
c) in erosion resistant castables applied by manual compacting.

4.9.2 For regions subjected to coke formation, 4% (in mass) of metallic fibers shall be added, both for dense and insulating concrete, with the exception of 4.9.1

4.9.3 For regions not subject to coke formation, it is recommended to add a maximum of 3% (by mass) of metallic fibers in dense concretes and 4% in insulators, with the exception of 4.9.1. [Recommended Practice].

4.10 On the surfaces to refracted, subject to corrosion by condensation of gases containing sulphur and/or vanadium compounds, an anti-corrosion protection shall be applied on plates.

4.11 When there is a modification of the pipeline layout or installation of accessories (valves, expansion joints, flanges, supports, etc), the detailed design shall evaluate the possibility of damage caused by the change of flexibility and dynamic behavior (vibration) of the system. If it is identified that the original design of the refractory lining is not suitable for the new service condition, actions to ensure the integrity of the pipeline shall be taken (change of the specification of castable refractory , content of metallic fibers, the anchorage system, or even the adoption of "hot wall").

4.12 For field splices with thicknesses equal to or greater than 50 mm, the following shall be met the following requirements:

a) For spacing greater than 80 mm between faces, the installation of anchoring clamps;
b) In the case of applying concrete by pouring in the field splice, care is taken in relation to the inclination of the edges, to avoid the formation of pockets of air;
c) In the case of applying concrete by tamping or pneumatic projection in the splice, the slope of the edges shall be into the concrete (negative chamfer).

5 Selection of Refractory Lining

5.1 Furnaces

5.1.1 In the radiant section zone (see Figure A.1, of Annex A) the following criteria may be adopted: **[Recommended Practice]**

a) furnaces operating at a wall temperature of 1 000 °C or lower:
   — single layer of insulating castable, class A or B, with or without fibers, anchored by “V” anchor and provided that the total thickness of the lining does not exceed 200 mm;
   — if it is impossible to use a single layer, adopt double layer, the 1st layer being of insulating castable, class B or C, or calcium silicate ABNT NBR 10662, Type III or ceramic fiber board PETROBRAS N-1890, and the the 2nd layer of insulating castable, class A or B, with or without fibers, anchored by “Y” anchor;
b) furnaces operating at wall temperature between 1 000 °C and 1 200 °C: double layer, the 1st layer being of insulating castable, class A or B, or calcium silicate ABNT NBR 10662, Type III or ceramic fiber board PETROBRAS N-1890, and the 2nd layer of semi-insulating castable, anchored by “Y” anchor.

NOTE 1 In the floor region, the last layer must be constituted of dense silica-aluminum refractory bricks or regular dense castable, or semi-insulating castable, being not necessary in the other layers the use of anchorage devices and metallic fibers.
NOTE 2 Do not use calcium silicate and ceramic fiber board as the 1st layer on roofs or transition zones (edges) of roofs to convection.

5.1.2 Castable selection shall be made considering the operating conditions of the furnace, paying special attention to the operating temperature, sulphur and/or vanadium contents and melting materials present in the combustible oils burned in the furnace.

5.1.3 It is recommended that primary and secondary blocks of burners are made of high-alumina refractory with pyrometric cone equivalent to “Orton Cone” 34 or above. (temperature of 1 763 °C). **[Recommended Practice]**

NOTE For burners that present excessive tiles wearing, it is recommended the use of parts formed by mullite. **[Recommended Practice]**

5.1.4 In the transition zone of radiation to convection sections (see Figure A.1, of Annex A) the same criterion adopted in radiation may be used. **[Recommended Practice]**

5.1.5 In the convection section zone (see Figure A.1 of Annex A) the following criteria shall be adopted:

a) single layer of insulating castable, class A, class B or semi-insulating castable (see 5.1.2), with or without metallic fiber, anchored by "V" anchor, provided that the total thickness of the lining does not exceed 150 mm;

b) if it is impossible to use a single layer, adopt double layer, the 1st layer being of insulating castable, class B or C, or calcium silicate ABNT NBR 10662, Type III or ceramic fiber board PETROBRAS N-1890, and the 2nd layer of insulating castable, class A or B, or semi-insulating castable (see 5.1.2), with or without metallic fiber, anchored by "Y" anchor.

5.1.6 In the transition zone between convection and the stack (breeching), in hot gas ducts and in cold gas ducts (see Figures A.1 and A.2 of Annex A), it may be adopted a single layer of insulating castable, class A or B, or semi-insulating castable (according to 5.1.2), with or without fibers, anchored by a "V" anchor. **[Recommended Practice]**

5.1.7 In hot gas ducts (see Figure A.2 of Annex A), it may be adopted a single layer of insulating castable, class A or B, with or without fibers, anchored by a "V" anchor. **[Recommended Practice]**

5.1.8 In the secondary blocks of the burners and on plate edge and on tops of walls, roofs and floor, as well as on the edge of walls, roofs and floors among themselves, and when assembling ready-made modules, there shall be an expansion joint (see Figure A.1 of Annex A), complying with the following requirements:

a) the expansion joint shall be filled with ceramic fiber surface PETROBRAS N-1890 folded and compacted;

NOTE 1 The expansion joints between ready-made modules shall be installed before the modules are assembled.

b) the opening of the expansion joints shall be 12 mm;

NOTE 2 For expansion joints between ready-made modules, the opening may be up to 20 mm.

c) the ceramic fiber surface in contact with castable refractories shall be involved with a 0.05 mm thick aluminum sheet or 0.10 mm polyethylene sheet, with minimum superposition of 50 mm, fixed with adhesive paper tape.

NOTE 3 It is allowed not to use the ceramic fiber board in expansion joints of prefabricated modules.

5.1.9 In the region of cross beams or girders, lining shall be performed according to Figure A.3 of Annex A, adopting the same criterion of the convection section zone, substituting the anchorage in the line of the girders by a trident anchor.

5.2 Stack

On stacks (see Figure A.1 of Annex A), it shall be adopted a single layer of class A insulating or semi-insulating castable (according to 5.1.2), with or without fibers, anchored by a "V" anchor.

5.3 Fluid Catalytic Cracking Unit - FCCU

5.3.1 Regenerator

In the regenerator (see Figure A.4 of Annex A) the following criteria shall be adopted:

a) shell: single layer of class A insulating castable, with or without metallic fibers, anchored by “V” anchor;
b) pipe grid: single erosion resistant lining, class A or B, anchored by “C”, Crown or “S” anchors, hexagonal type I or II mesh, or articulated mesh;
c) cyclones: single, class A, erosion resistant lining, without metallic fiber, anchored by type I or II hexagonal mesh;

5.3.2 Disengager Vessel (Reactor)

In the disengager vessel (see Figure A.4 of Annex A) the following criteria shall be adopted:

a) cold wall vessel: single layer of semi-insulating or class A insulating castable, with metallic fiber, anchored by “V” or “wavey V” anchor;
b) hot wall vessel: single layer of erosion resistant class A or B castable, without metallic fiber, anchored by type II hexagonal type mesh or articulated mesh;
c) cyclones: single lining of erosion resistant class A or B castable, without metallic fiber, anchored by type II hexagonal type mesh or articulated mesh.

5.3.3 Riser

As a result of the riser wall type (see Figure A.4 of Annex A) one the following criteria shall be adopted:

a) cold wall riser: single layer of low cement erosion resistant castable, class C, with metallic fiber, anchored by “wavey V” anchor and applied by external vibration. For field joints, use anti-erosion concrete, class C, applied by free flowing, or anti-erosion concrete, class A, applied by tamping.

NOTE 1 In the crossover, double-layer coating can also be adopted, with the 1st layer of dense anti-erosion concrete, class A, without fibers, anchored by clamps "C", Crown or "S" and the 2nd layer of anti-erosion concrete, low cement, class C, with metallic fibers, anchored by wavy “V” clamp and applied by free fluency**. [Recommended Practice]**

NOTE 2 In the “Y” or “J” part, a single layer of low-grade anti-erosion concrete, class C, with metallic fibers, anchored by a wavy “V” clamp and applied by free creep or external vibration can also be adopted. **[Recommended Practice**

b) hot wall riser: single layer of erosion resistant class A or B castable, without metallic fiber, anchored by type II hexagonal type mesh.

5.3.4 Stripper External to Regenerator

As a result of the stripper wall type (see Figure A.4 of Annex A) one the following criteria shall be adopted:

a) cold wall vessel: single layer of medium weight heat insulating castable or class A insulating castable, with metallic fibers, anchored with “V” anchor;
b) hot wall vessel: single layer of erosion resistant class A castable, anchored with type I or II hexagonal type mesh, articulated mesh, or “C” anchor.

5.3.5 Stripper Internal to Regenerator

In this configuration, the stripper has 2 parts. One between the disengager vessel cone until the regenerator inlet (external part) and the other internal to the regenerator (internal part):

a) external part (cold wall): single layer of medium weight heat insulating castable or class A insulating castable, with metallic fibers, anchored with “V” anchor;
b) internal part (hot wall):
   — internal side: single layer of erosion resistant class A castable, anchored with type I or II hexagonal type mesh, articulated mesh, or “C” anchor;
   — external side: single layer of medium weight heat insulating castable or class A insulating castable, with metallic fibers, anchored with “V” anchor, covered by perforated plate, according to Notes 1 and 2.

NOTE 1 Perforated plate; stainless steel 304, round holes with 2” diameters, alternate disposition, 1/8” thickness, width of 1 200 mm, length 2 000 mm and distance between centers of 3” holes.

NOTE 2 The assembling of the perforated plate is made by tapped pins (table type) in stainless steel 304, spaced by 500 mm x 500 mm, with height of 50 mm more than the thickness of the castable lining (the tapped part must have, at least, 60 mm), so as to allow the placement of the perforated plate, with pins left for placement of the respective table, and to weld the table locking with the pin (tack welding).

5.3.6 Standpipe

5.3.6.1 Standpipe External to Regenerator

a) according to a) of 5.3.3 (cold wall);
b) according to b) of 5.3.3 (hot wall).

5.3.6.2 Standpipe Internal to Regenerator

According to b) of 5.3.5.

5.3.7 Flue Gas Line

In the flue gas line (see Figure A.4 of Annex A), the criteria described in 5.3.7.1 and 5.3.7.2. may be adopted.**[Recommended Practice]**

5.3.7.1 Flue Gas Line - FCCU

a) single layer of erosion resistant refractory, class C, with or without metallic fiber, anchored by “V” anchor, with thickness of 75 mm or above;
b) double layer, the 1st being an insulating castable layer, class A, the 2nd layer in class C erosion resistant castable, with or without metallic fiber, anchored by a “Y” anchor, and the 2nd layer shall have thickness of 75 mm or above.

NOTE A single layer of class A insulating or medium weight heat insulating castable may be used, with or without metallic fibers, anchored by a “V” anchor, with thickness of 75 mm or above, provided that the low erosion of gases is ensured. **[Recommended Practice]**

5.3.7.2 Flue Gas Line - RFCCU

a) section between the regenerator and the 3rd stage vessel: double layer, the 1st layer being in class A, insulating castable, the 2nd layer being in class C erosion resistant castable, with or without metallic fibers, anchored by an "Y" anchor, and the 2nd layer shall have thickness of 75 mm or above;
b) section after 3rd stage vessel: single layer of class A insulating or medium weight heat insulating castable, with or without metallic fiber, anchored by "V" anchor.

5.3.8 Orifice Chamber

In the orifice chamber (see Figure A.4, of Annex A) the following criteria may be adopted: **[Recommended Practice]**

a) region without internal shround: single layer of regular castable, class A, erosion resistant castable, class C, with metallic fiber, anchored by "V" anchor;

NOTE For region subject to vibration (downstream the slide valve), the refractory castable shall be anchored by tempered heat treated "wavey V" anchor.

b) region with internal shround: single layer of class A or B insulating castable, with or without metallic fibers, anchored by "V" anchor;
c) hot wall side: single layer of erosion resistant class A or B castable, anchored by type II hexagonal type mesh.

5.3.9 Sealing Pots

In the sealing pots, the following criteria may be adopted: **[Recommended Practice]**

a) region below water level: single layer of erosion resistant castable, class C, with or without metallic fiber, anchored by "V" anchor;
b) region above water level: according to one of the alternatives adopted for flue gas lines (according to 5.3.7.1).

5.3.10 3rd Cyclone Stage Vessel

In the 3rd stage vessel (see Figure A.4 of Annex A) the following criteria shall be adopted:

a) shell: according a) of 5.3.1;
b) cyclone: according c) of 5.3.1.

5.3.11 Cat Cooler

In the cat cooler (see Figure A.4 of Annex A), the criteria shall be in accordance with a) of 5.3.3.

5.3.12 Diverter Valve

In the valve (see Figure A.4 of Annex A), the following criteria shall be adopted:

a) shell: according a) of 5.3.3;
b) disc: according c) of 5.3.1.

NOTE In the FCCU regions, where the geometry does not allow installation of the given mesh, anchorage may be performed by using "C", crown or "S" anchors. **[Recommended Practice]**

6 Material Selection, Layout and Welding of Anchorage Devices

In the selection of the material of the anchorage devices, the following criteria shall be adopted:

a) Furnace: according to API STD 560;
b) FCCU: according to Table 1.

Table 1 - Material of the Anchorage Devices for FCCU

Region			Material		
			Equipment	Protected anchorage ("V","Y"anchor, etc.)	Open anchorage (hexagonal, articulated mesh, C, L, S, U, crown anchor, etc.)
Regenerator:	Side		SA-516 Gr 70 or 60	AISI 304	AISI 304
	Internals		SST 304H	AISI 304	AISI 304
	Plenum:	External	SA-516 Gr 70 or 60	AISI 304	AISI 304
		Internal	SST 304H		
Separator vessel/ stripper:	Side		SA-516 Gr 70 or 60 SA-387 Gr 11 Cl 2	AISI 410S/304	AISI 410S
	Internals		Alloy Steel 11/4 Cr-1/2Mo	AISI 410S/304	AISI 410S
	Plenum:	External	SA-516 Gr 70 or 60	AISI 410S/304	AISI 410S
		Internal	SA-387 Gr 11 Cl 2		
Riser:	External		SA-516 Gr 70 or 60	AISI 304	AISI 304 AISI 410S
	Internal		SA-387 Gr 11 Cl 2		
Cat cooler			SA-516 Gr 70 or 60	AISI 304	AISI 304
Worn catalyst standpipe:	External		SA-516 Gr 70 or 60	AISI 410S/304	AISI 410S
	Internal		SA-387 Gr 22 Cl 2		
Regenerated catalyst standpipe			SA-516 Gr 70 or 60	AISI 304	AISI 304
Sliding valve or plug			SST 304H	AISI 304	AISI 304
Gas recovery section:	Pipes		SA-240 Gr 304H	AISI 304	AISI 304
	Orifice chamber				
	Sealing pot / diverter valve				
Third Stage System (TSS):	Third stage vessel		SA-516 Gr 70 or 60	AISI 304	AISI 304
	Internals		SST 304H		
	4th Stage		SA-240 Gr 304H		
	Fine receiver		SA-516 Gr 70 or 60		
NOTE The decision on the choice of the anchorage material shall be made regarding the metal where it will be installed and the temperature levels.					

6.1 Hexagonal and Articulated Meshes

6.1.1 Fixation of the mesh for lining in single layer can be according to Figures A.5.1, A.5.2 and A.5.4 of Annex A . In regions subject to the formation of coke and/or subject to vibration, fixation of the mesh shall be reinforced, and according to Figures A.5.3 and A.5.5 of Annex A.

6.1.2 Fixation of the hexagonal mesh, for double layer (see Figure A.6 of Annex A), may be according to the following scheme: **[Recommended Practice]**

a) distribute the fixation anchors (tapped or welded) in centered square formation, with spacing of 200 mm to 250 mm; in regions subject to the coke formation and/or subject to vibration; the spacing recommended is 150 mm;
b) position the mesh above the anchors, executing the welding of fixation of the mesh to the coinciding anchors, only one side of each strap, across the contact region, in the longest section.

NOTE When there is a coincidence of 2 straps, the 2 sides shall be welded.

6.1.3 It is recommended that the meshes are arranged in such a manner that the product flow is as perpendicular as possible to the straps that form the hexagons (see Figures A.5, A.6, and A.7 of Annex A). **[Recommended Practice]**

6.1.4 In case of a junction of 2 parts (in the assembly phase) previously coated with mesh, a section shall be left without lining (without anchorage) at least 100 mm from the border. After the field welding of the parts, the lining is completed, as per Figure A.7 of Annex A.

6.1.5 The longitudinal seam between the meshes may be phased out for at least 100 mm (see Figure A.7 of Annex A).

6.1.6 For the union between the mesh panels, alternatives of Figure A.8 of Annex A may be used, and the seams shall be welded to the side.

6.1.7 The single layer meshes, when not joined to each other, may have a terminal bar, and in changes of direction, they may be finished with “L” anchors, according to Figure A.9 of Annex A. **[Recommended Practice]**

6.1.8 On the side of reactors subject to the formation of coke and subject to bloating and superposing, it is recommended the installation of independent panels, with or without terminal bar, according to Figure A.18 of Annex A. **[Recommended Practice]**

6.1.9 In the case of transition from double layer lining to single layer lining, the details of Figure A.10 of Annex A shall be followed. **[Recommended Practice]**

6.2 “V” Anchor

6.2.1 The distribution and fixation of “V” anchors shall be in the form of a triangle (see Figures A.11 of Annex A).

6.2.2 In cylindrical internal regions (example: chimneys), the spacing of anchor base shall be increased, in order to avoid interference between the ends of adjacent anchors. Similarly, in cylindrical external regions (example: FCCU standpipe), the spacing of anchor base shall be reduced, in order to avoid the excessive distance between the ends of adjacent anchors.

6.3 “Y” Anchor

6.3.1 The distribution and fixation of “Y” anchors shall be in the form of a triangle (see Figure A.12 of Annex A).

6.3.2 In the case of ceilings, in addition to the “Y” anchors, ancillary “V” anchors, sized in function of the thickness of the 1st layer, shall be fixed. (see Figure A.13 of Annex A).

6.3.3 In cylindrical internal regions, the spacing of anchor base shall be increased, in order to avoid interference between the ends of adjacent anchors. Similarly, in cylindrical external regions, the spacing of anchor base shall be reduced, in order to avoid the excessive distance between the ends of adjacent anchors.

6.4 “S” Anchor

6.4.1 The distribution and fixation of “S” anchors shall be in accordance with Figure A.14 of Annex A. **[Recommended Practice]**

6.4.2 In the case of junction of 2 parts (assembly) previously coated with “S” anchors, the finish may be made according to Figure A.14.3 of Annex A. **[Recommended Practice]**

6.5 Changes of Direction

In changes of direction (plan) of panels anchored with hexagonal or articulated mesh, or “S”, “Crown” or “C” anchors, the transition with “L” anchors shall be done, according to Figure A.9 of Annex A.

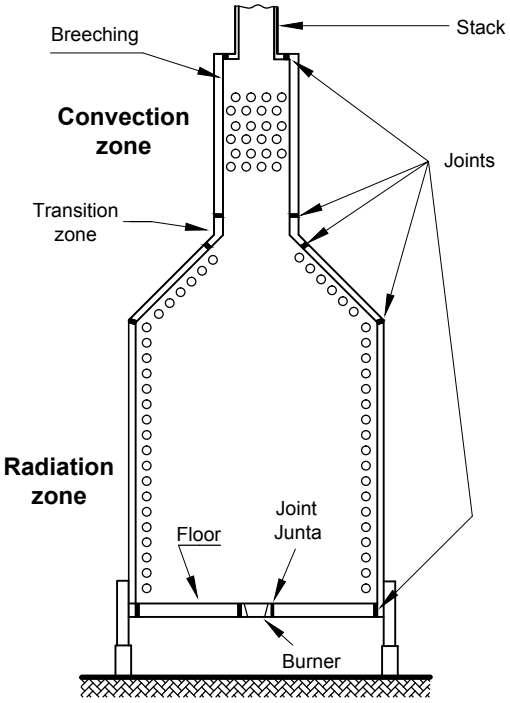
6.6 “Crown” Anchor

See Figure A.16 of Annex A.

6.7 “C” Anchor

See Figure A.17 of Annex A.

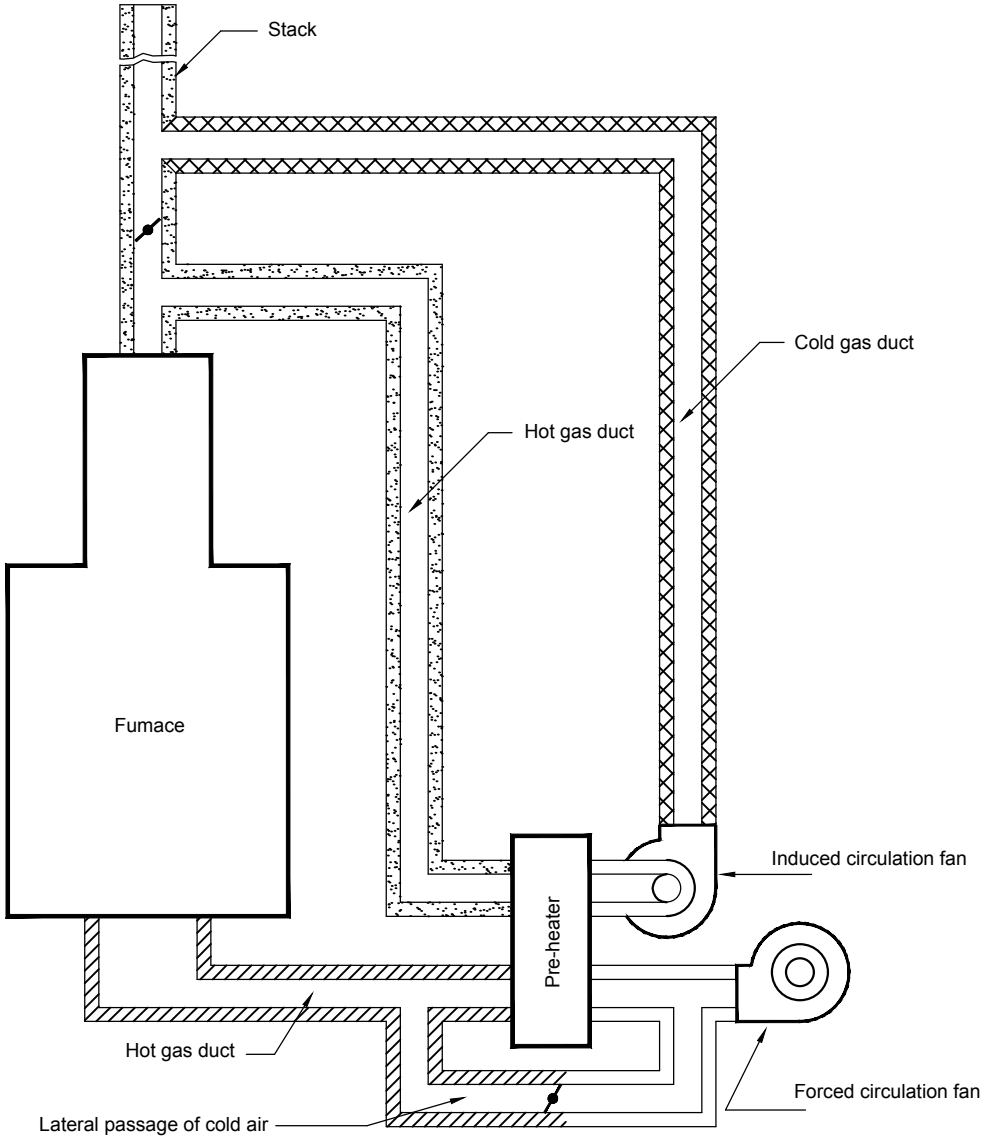
Annex A - Figures



Region	Wall temperatura (ºC)	Number of layers	Material of 1st layer	Material of 2nd layer	Observation
Radiation zone	T ≤ 1 000	Single	Insulating A or B	N/A	Up to 200 mm thickness
		Double	Insulating B or C or calcium silicate or ceramic fiber board (See Note 3)	Insulating A or B	
	1 000 < T ≤ 1 200	Double	Insulating A or B or calcium silicate or ceramic fiber board (See Note 3)	Semi-insulating	
Radiation convection Transition	T ≤ 1 000	Single	Insulating A or B	N/A	Up to 200 mm thickness
		Double	Insulating B or C or calcium silicate or ceramic fiber board (See Note 3)	Insulating A or B	
	1 000 < T ≤ 1 200	Double	Insulating A or B or calcium silicate or ceramic fiber board (See Note 3)	Semi-insulating	
Convection zone		Single	Insulating A or B or calcium silicate or ceramic fiber board (See Note 3)	N/A	Up to 150 mm thickness
		Double	Insulating B or C or calcium silicate or ceramic fiber board (See Note 3)	Insulating A or B or semi-Insulating	
Breeching		Single	Insulating A or B or semi-insulator	N/A	N/A
Stack		Single	Insulating A or semi-Insulating	N/A	N/A
Floor		Double or triple	Insulating A or B or C or semi-insulating	Regular or semi-insulating or dense brick	For triple layer: calcium silicate in 1st layer
Burner		N/A	High alumina refractory or mulite	N/A	CPE ≥ 34
Expansion joint		N/A	Ceramic fiber board	N/A	12 mm Thickness

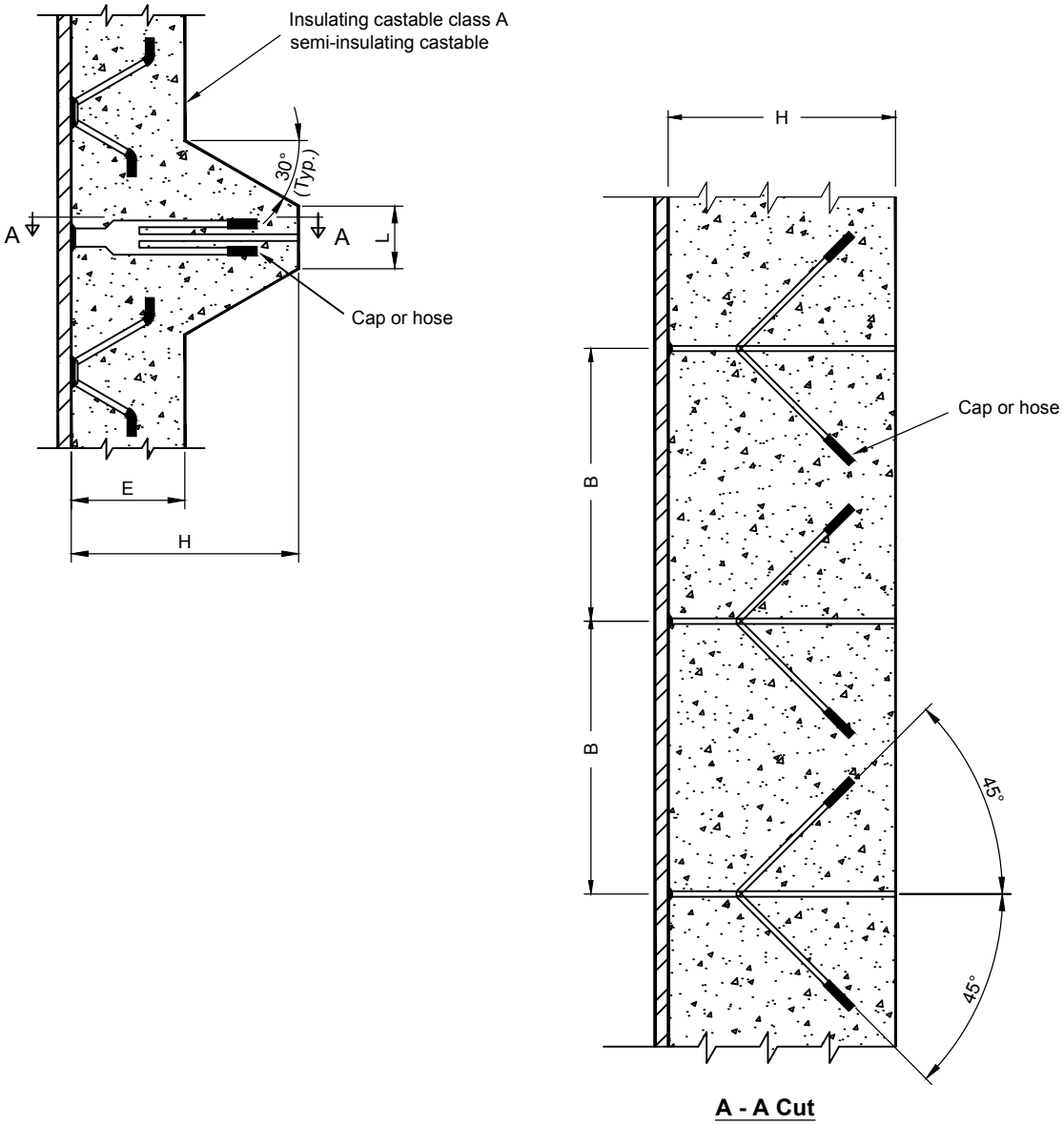
NOTE 1 For lining with calcium silicate or ceramic fiber board, use anchorage of Figure A.12
NOTE 2 For lining only insulating castable, use anchorage of Figures A.12 or A.13.
NOTE 3 Not utilize calcium silicate or ceramic fiber board in 1st layer of roofs or in transition zone to convection.

Figure A.1 - Refractory Lining in Furnace



Place	Material
Hot gas duct	Insulator A or B or Semi-insulator
Cold gas duct	Insulator A or B or Semi-insulator
Hot air duct	Insulator A or B

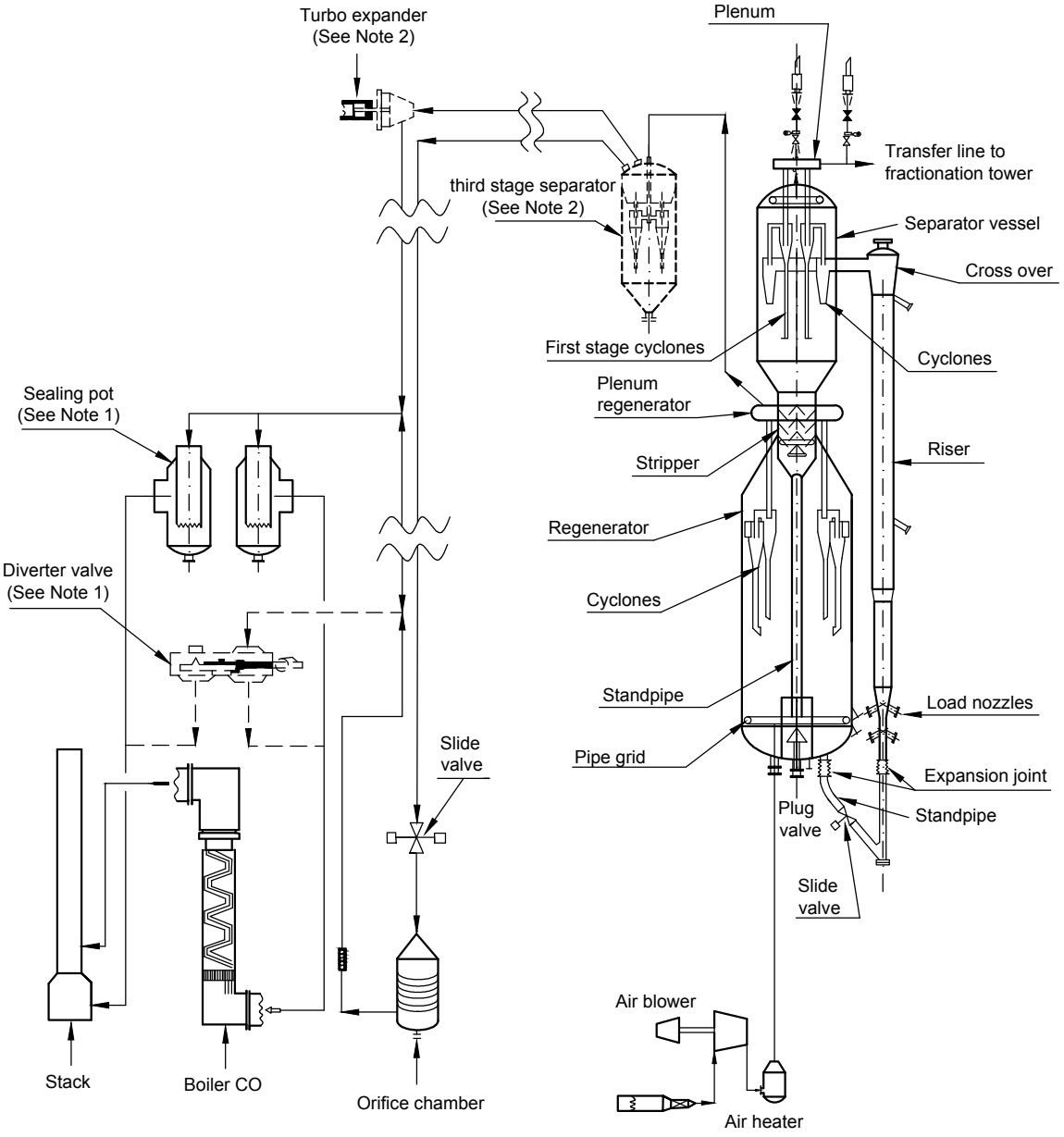
Figure A.2 - Refractory Lining in Pre-Heating System Furnance Air



H and L = defined in the project
E = Castable thickness
B = 1,2 H (minimum 200 mm)

NOTE After anchor welding open the lateral theeth as indicated in A-A cut .

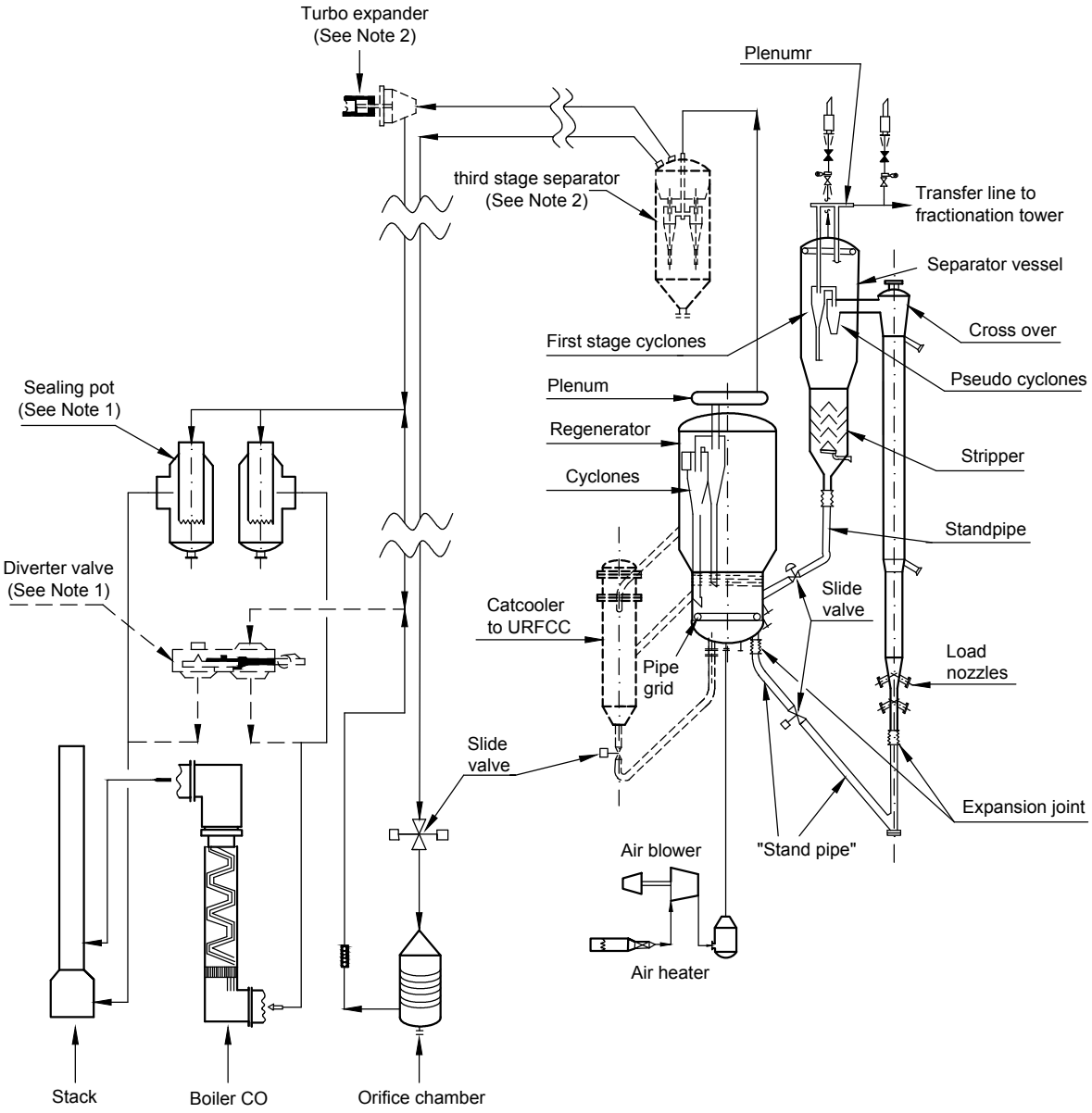
Figure A.3 - Cross Beam



NOTE 1 According to the unit project, should be only sealing pots or diverter valve.
NOTE 2 Nonexistent equipment in some units.

Figure A.4.1 - Orthoflow Type

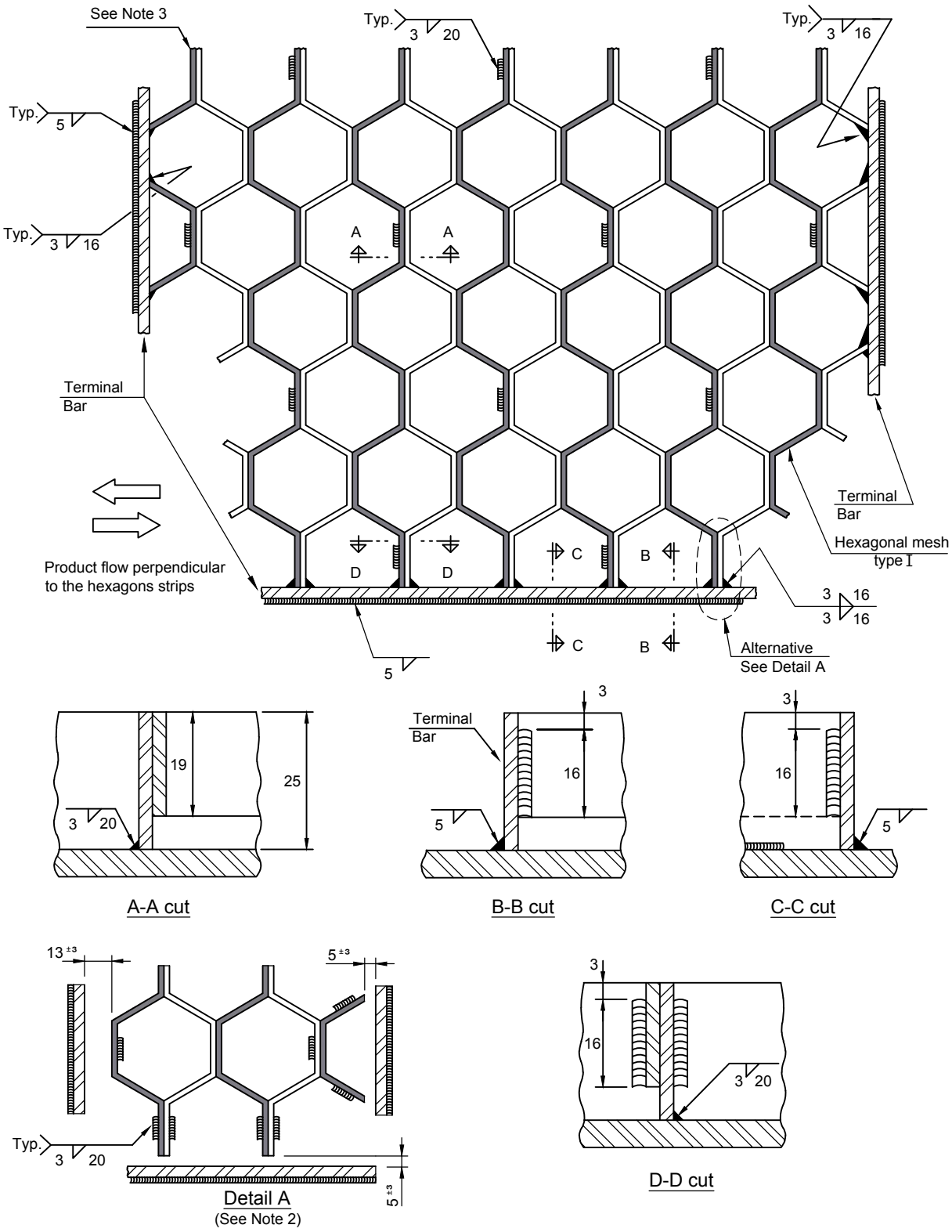
Figure A.4 - Fluid Catalytic Cracking Unit - FCCU



NOTE 1 According to the unit project, should be only sealing pots or diverter valves.
NOTE 2 Nonexistent equipment in some units.

Figure A.4.2 - Side by Side Type

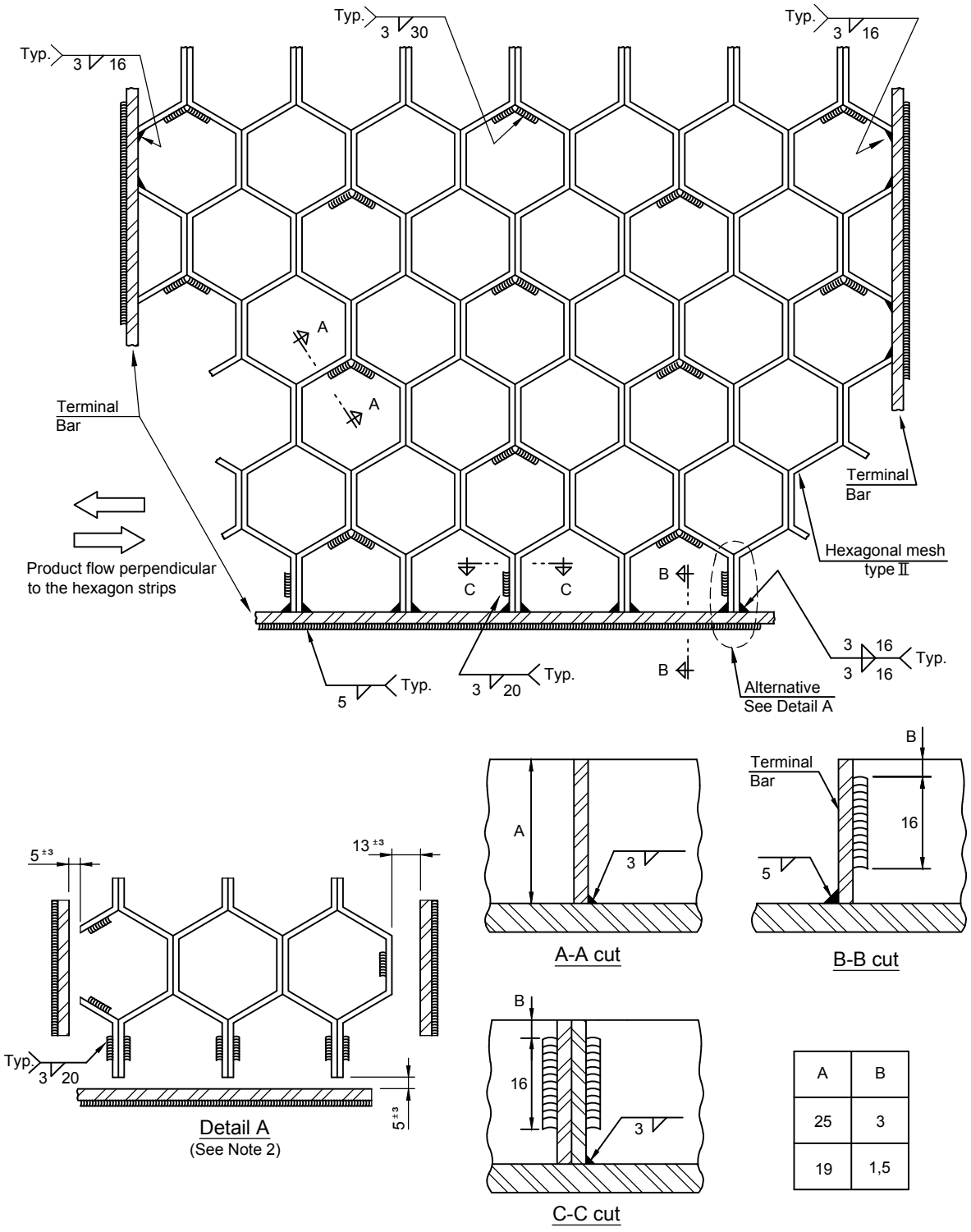
Figure A.4 - Fluid Catalytic Cracking Unit (FCCU)



NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Alternatively, admits to welding the ends of the hexagonal mesh directly on the side, avoiding welding on the terminal bar.
NOTE 3 The gray strips represent the 25 mm wide.

Figure A.5.1 - Hexagonal Type I for Single layer

Figure A.5 - Mesh Fixation

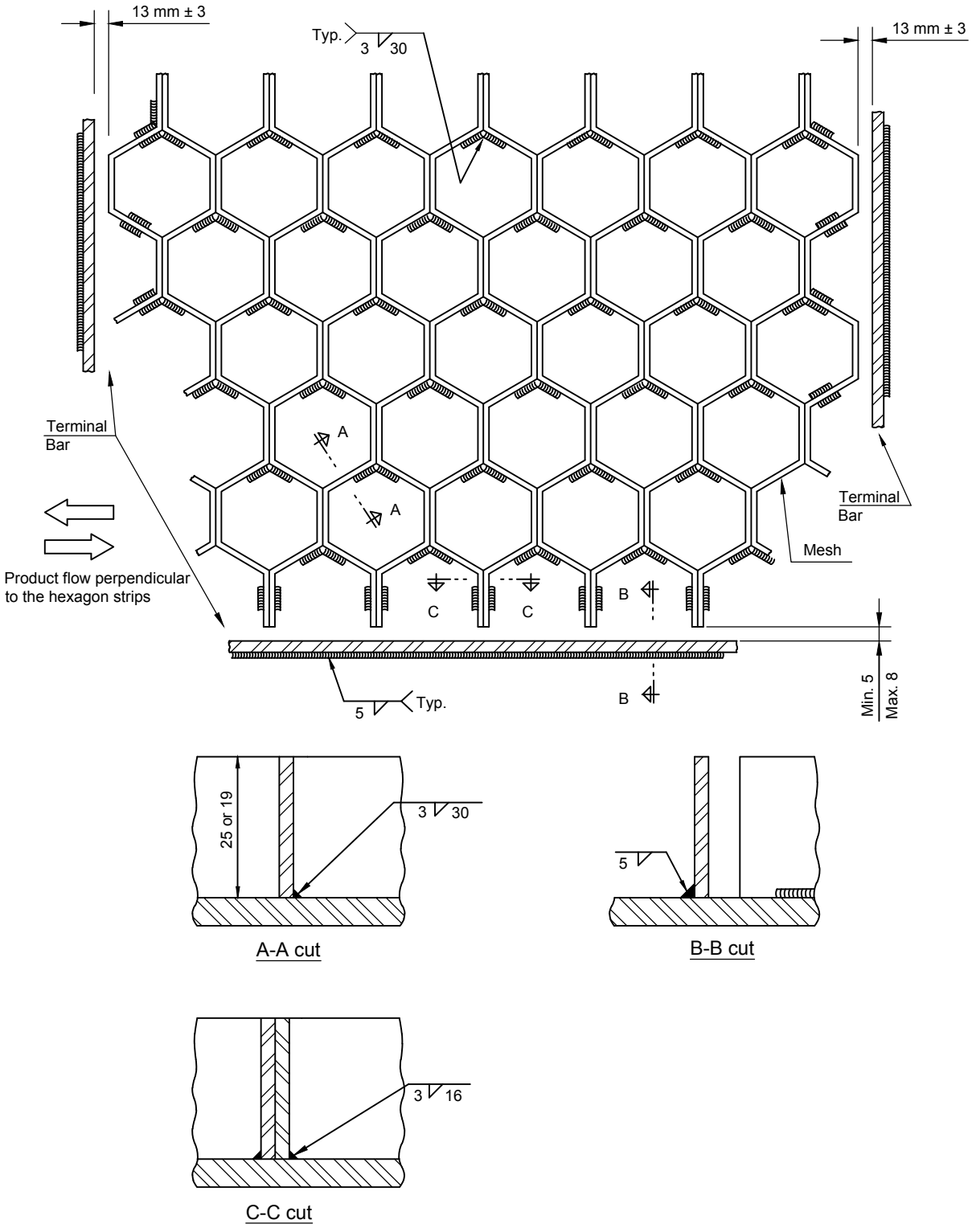


A	B
25	3
19	1,5

NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Alternatively, admits to welding the ends of the hexagonal mesh directly on the side, avoiding welding on the terminal bar.

Figure A.5.2 - Hexagonal Type II for Single Layer

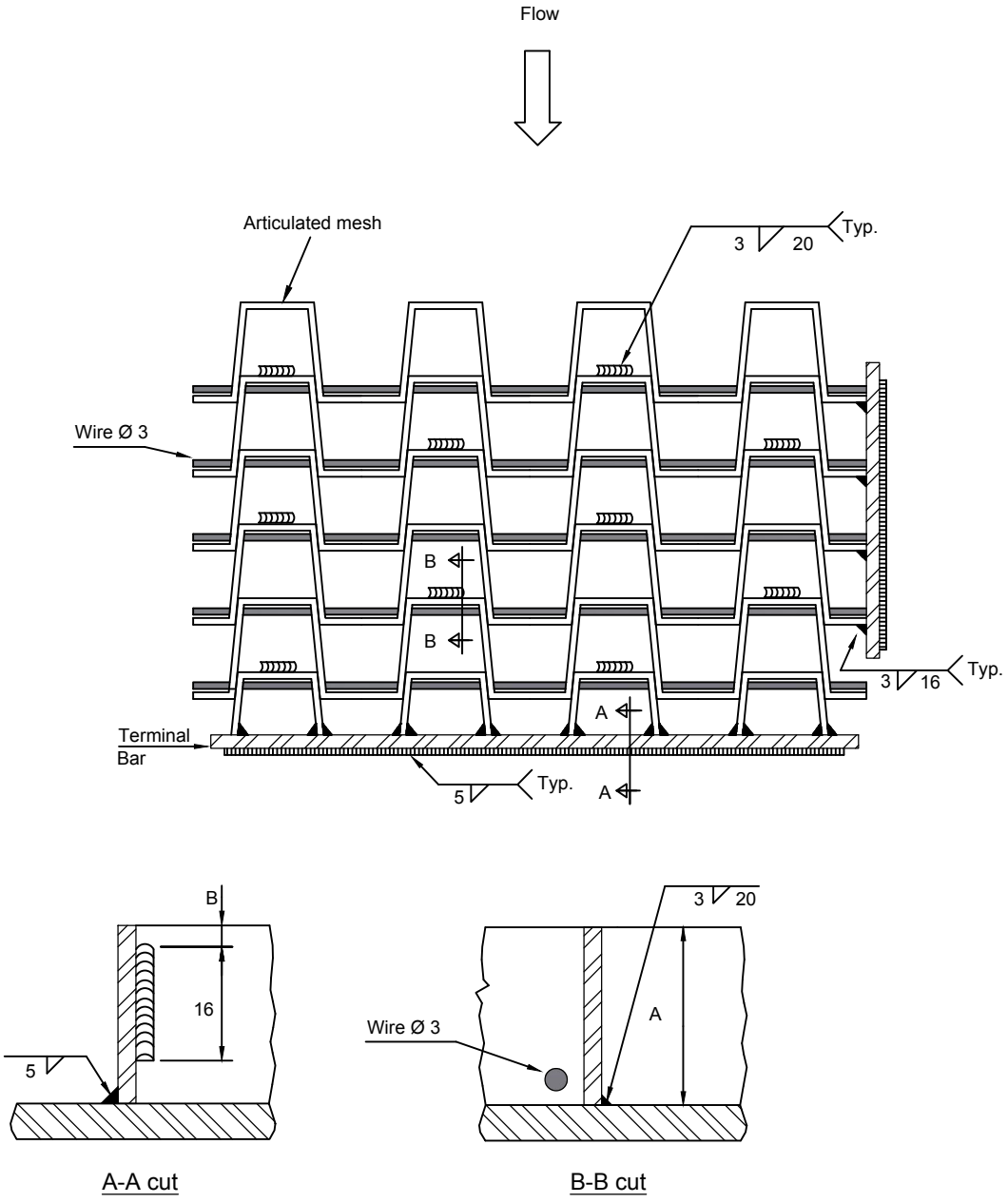
Figure A.5 - Mesh Fixation



NOTE Dimensions in millimeters, exept if otherwise indicated.

Figure A.5.3 - Hexagonal Type II for Single Layer (Regions Subject to Coke Formation and/or Vibration

Figure A.5 - Mesh Fixation

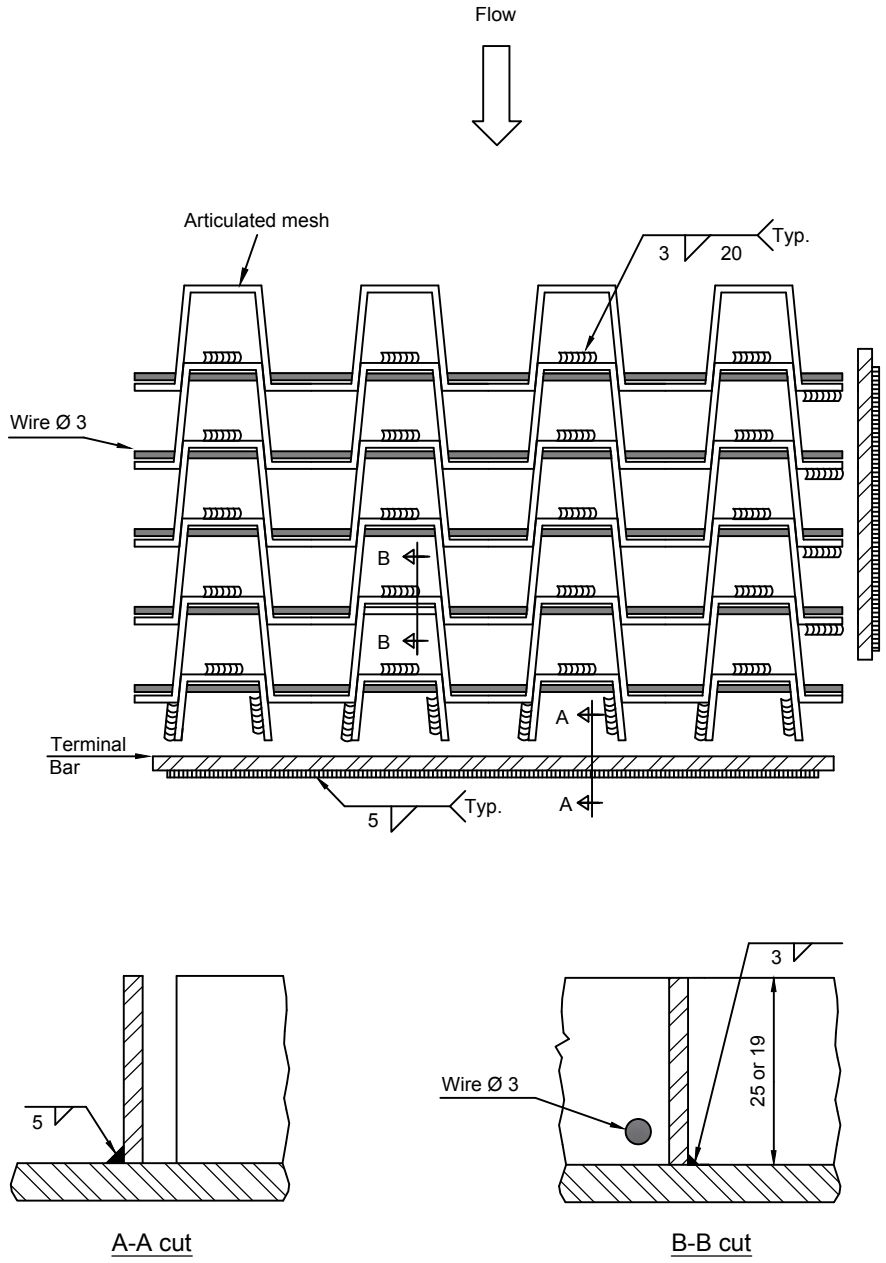


A	B
25	3
19	1,5

NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.5.4 - Articulated for Single Layer

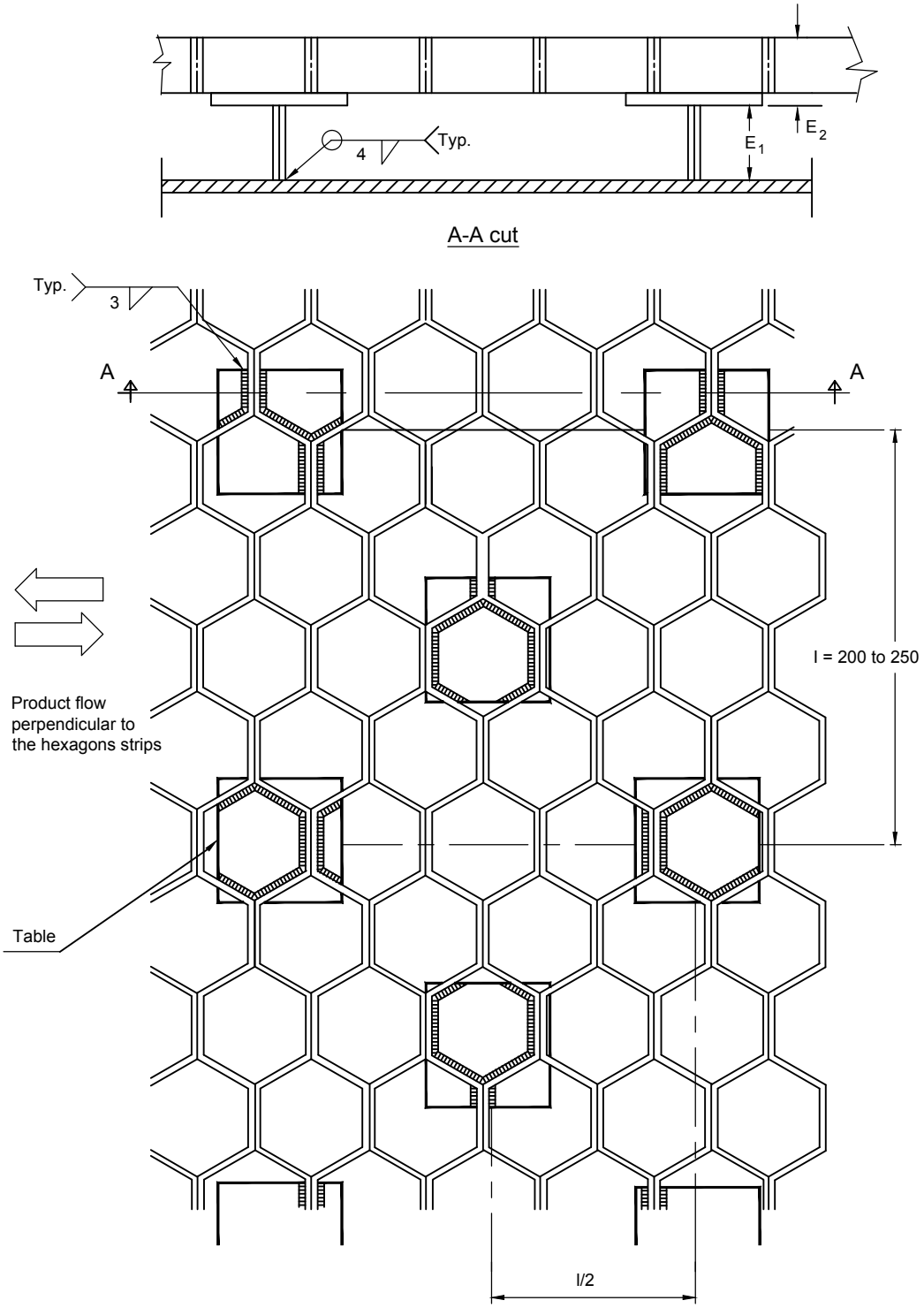
Figure A.5 - Mesh Fixation



NOTE Dimensions in millimeters, except if otherwise indicated.

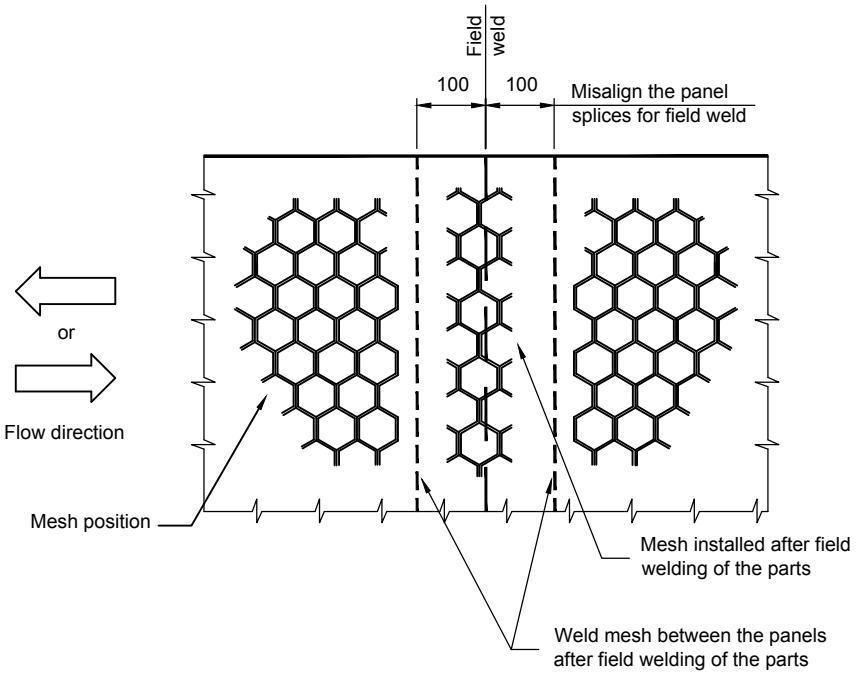
Figure A.5.5 - Articulated for Single Layer (Regions Subject to Coke Formation and/or Vibration)

Figure A.5 - Mesh Fixation

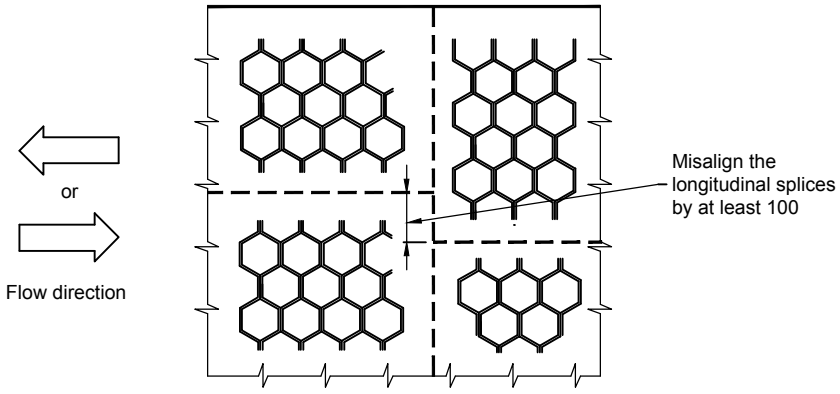


NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 All the strips must be welded on one side of the entire length of contact with the table.
NOTE 3 Select the side of greater course to do the welding.

Figure A.6 - Fixation of Hexagonal Mesh Type II for Double Layer



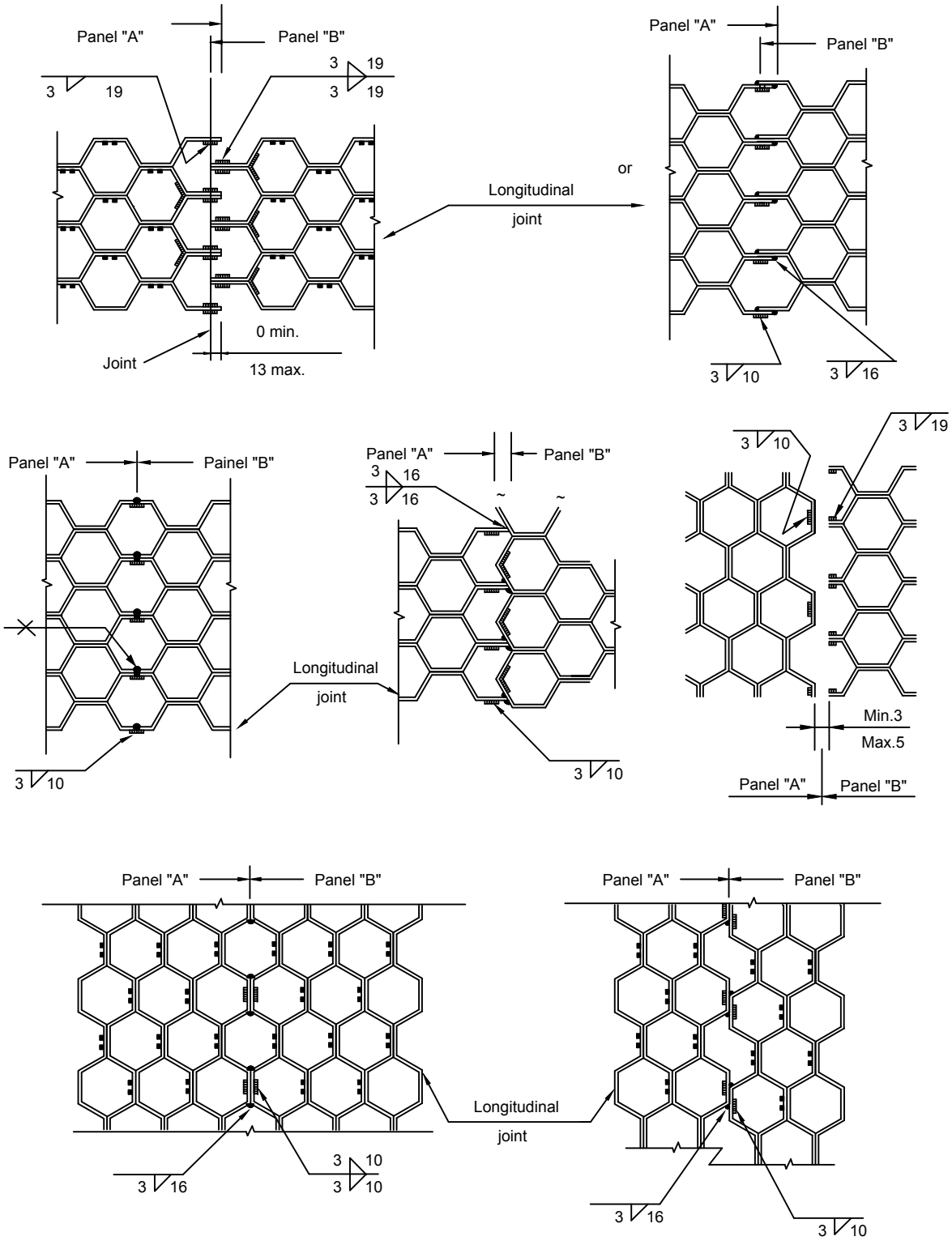
Splice of Hexagonal Mesh to Field Weld



Splice of Hexagonal Mesh in Panels

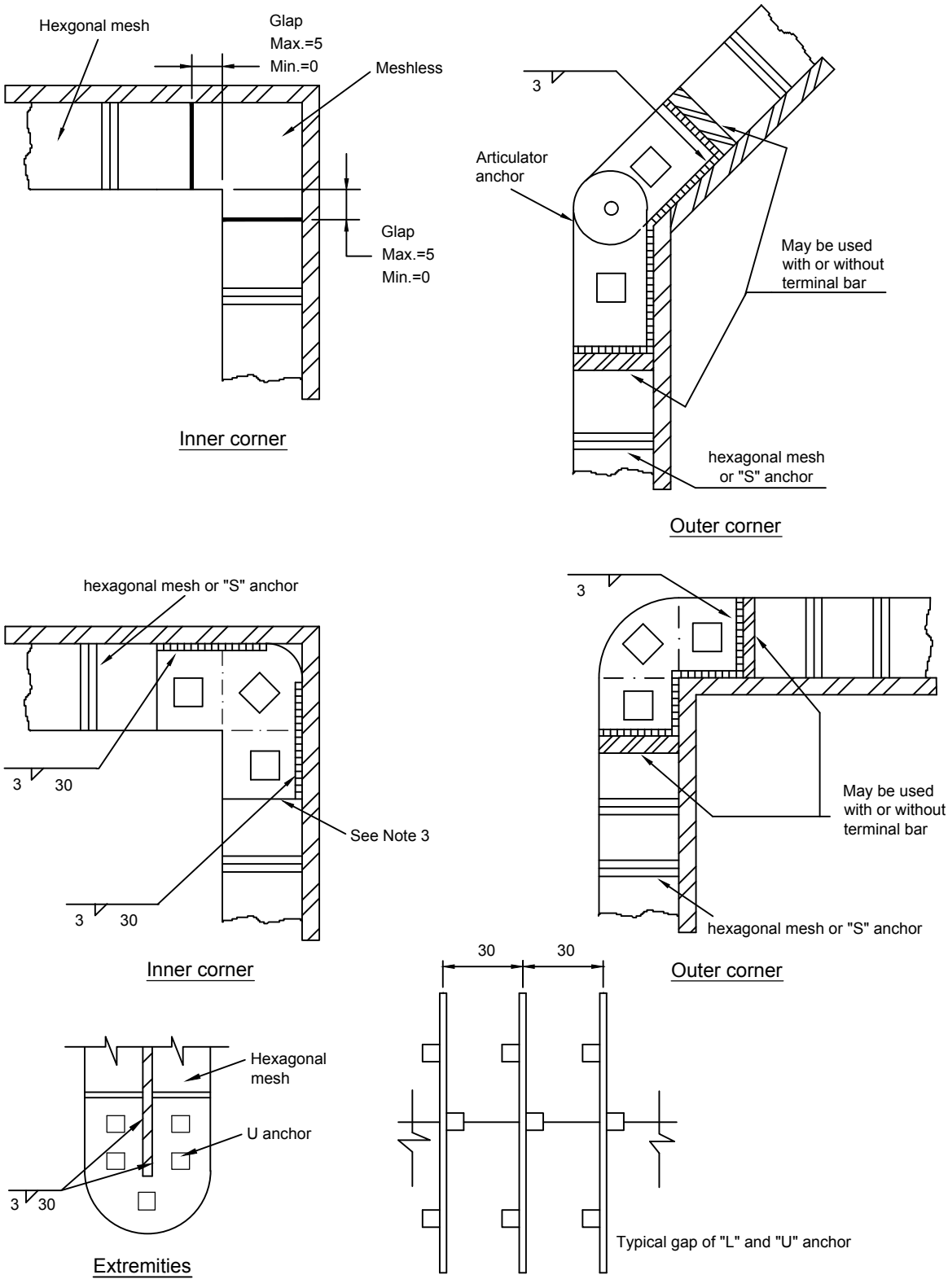
NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.7 - Instalation of Hexagonal Mesh Panel



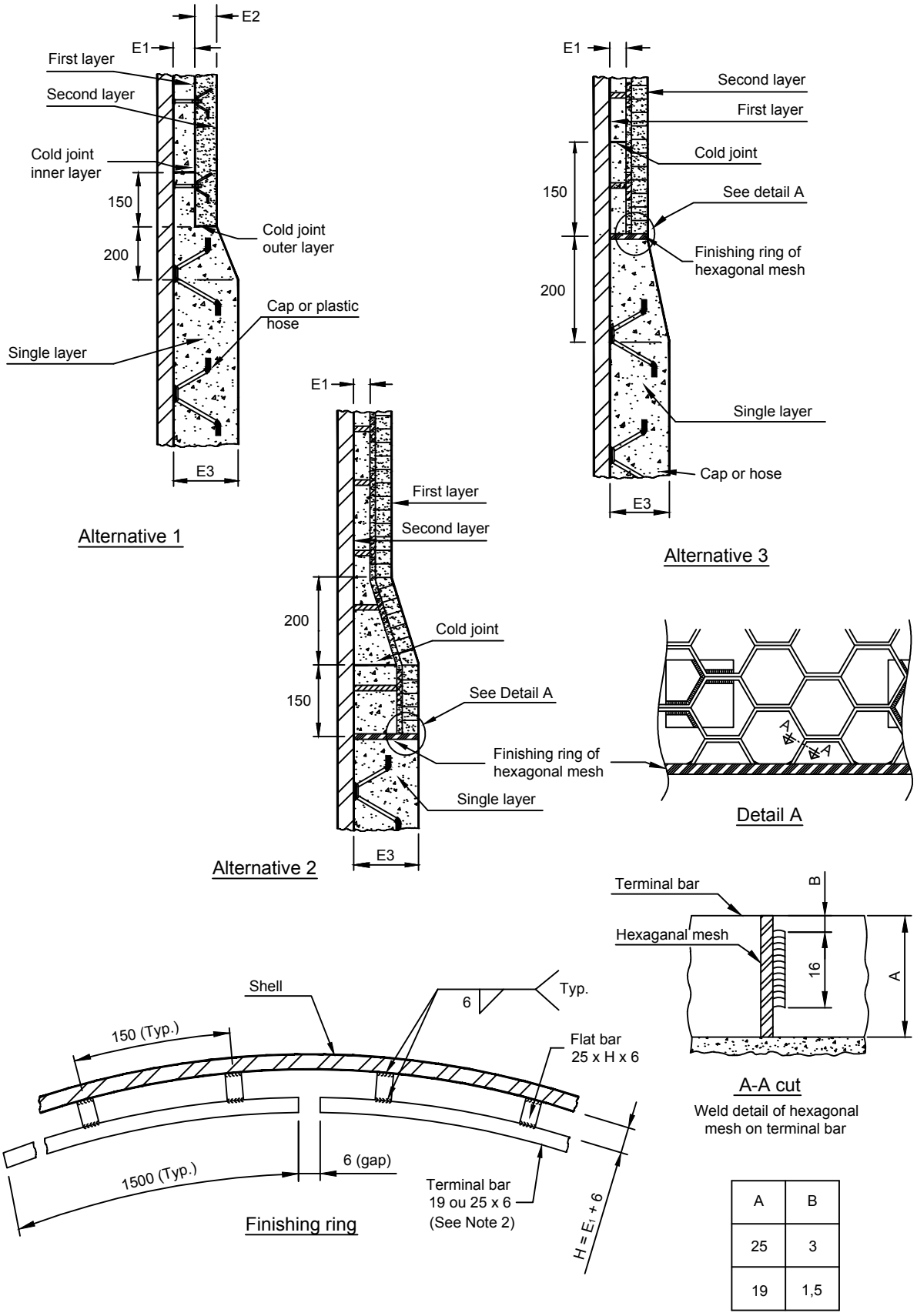
NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Areas generated in the splices must be between 0.50 and 1.50 of the original hexagon area.
NOTE 3 Splices of contact with shell must be welded on it.

Figure A.8 - Union of Hexagonal mesh Panels



NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Terminal bar should be used to all exposed edge.
NOTE 3 Weld the "L" clamp on the hexagonal mesh, always that there is a contact between mesh and clamp.

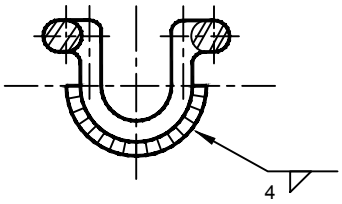
Figure A.9 - Details of Direction Change to Mesh Panels.



A	B
25	3
19	1,5

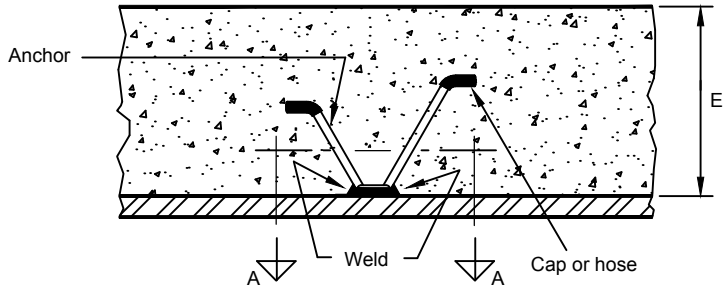
NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Width of the terminal bar according to thickness of hexagonal mesh.

Figure A.10 - Details of Transition from Double Layer to Single Layer

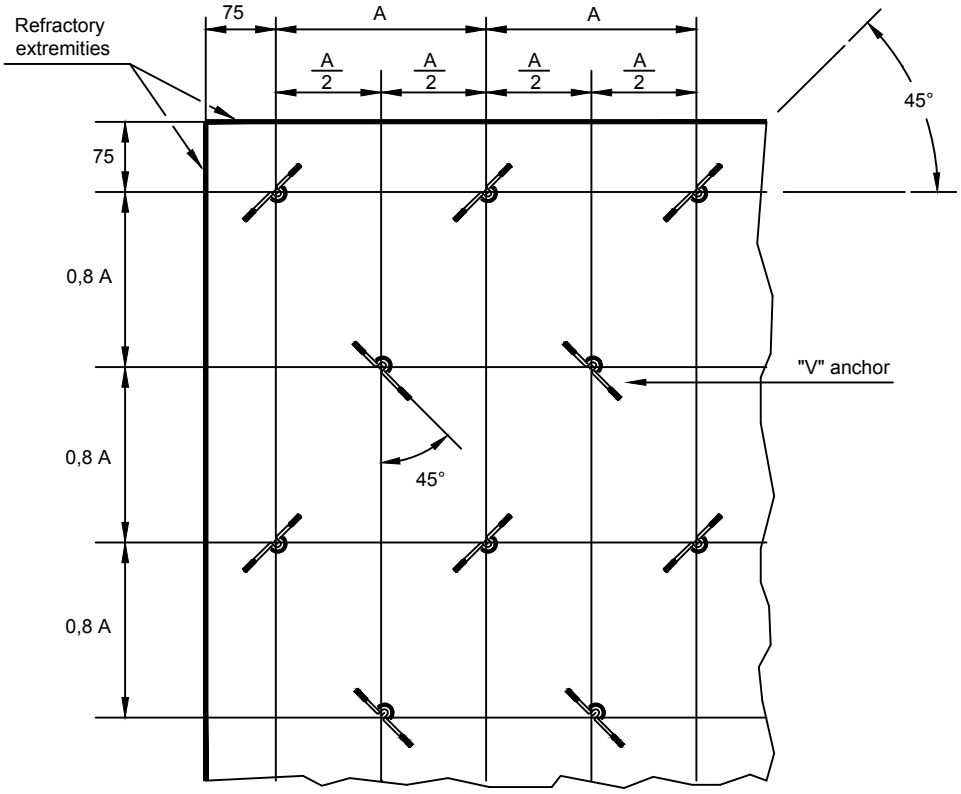


A-A cut

weld only in the outer rounded region



Anchor Fixation



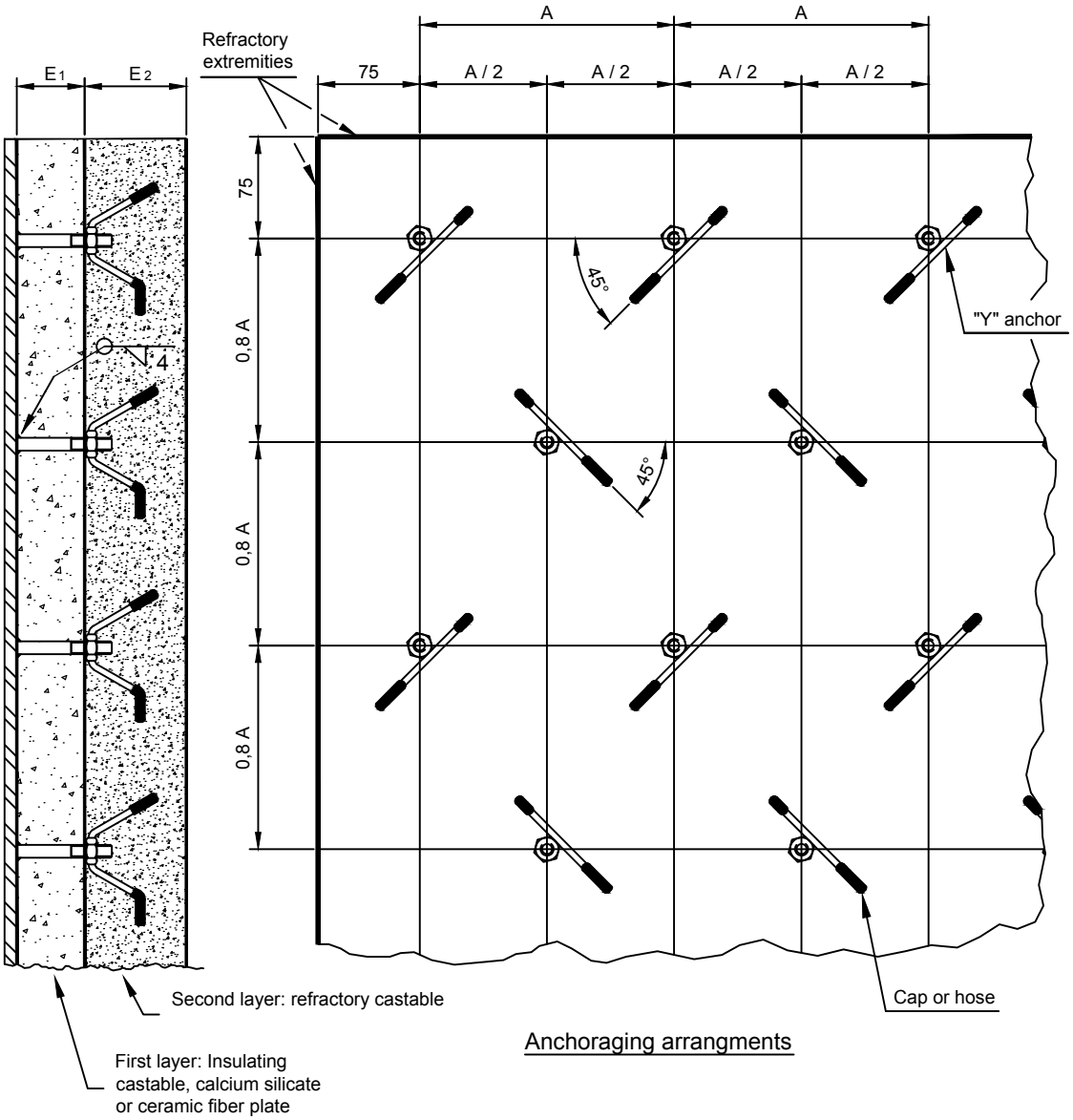
Anchoraging arrangments

E = Linging tickness

Walls A = 2E to 3E for E < 100;
A = 200 to 400 for E > 100.
Roofs A = 2E, maximum 300

NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.11 - Installation of "V" Anchor



Anchoraging arrangments

Anchor fixation

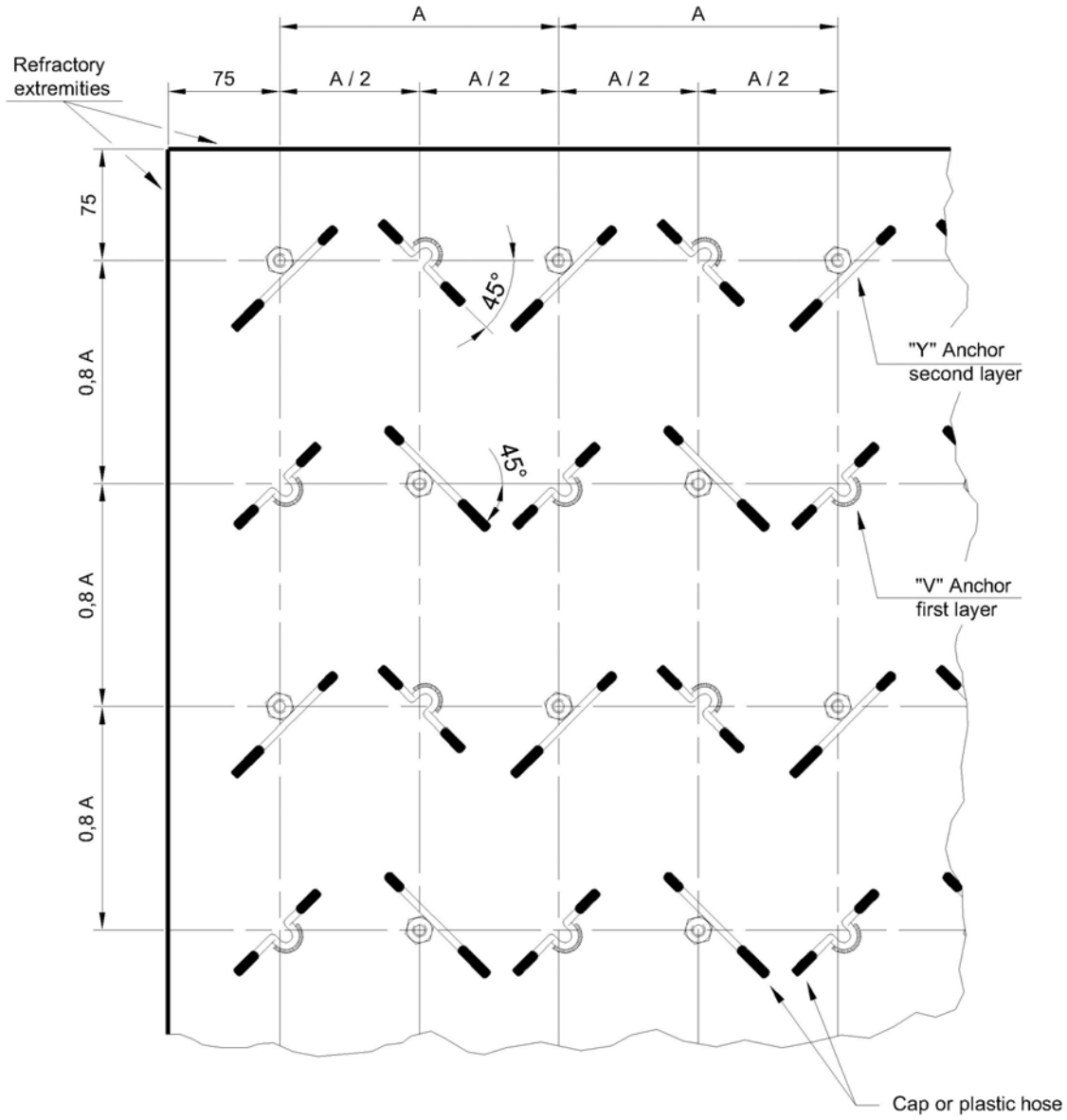
For walls:
$A = 2E_2$ to $3E_2$ for $E_2 < 100$
$A = 200$ to 400 for $E_2 \geq 100$

For ceiling:
$A = 2E_2$, maximum 300

Where:
$E \equiv$ Lining thickness ($E = E_1 + E_2$)
$E_1 \equiv$ First layer thickness
$E_2 \equiv$ Second layer thickness

NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.12 - Installation of "Y" Anchor



$A = 2E_2$, maximum 300

Where:

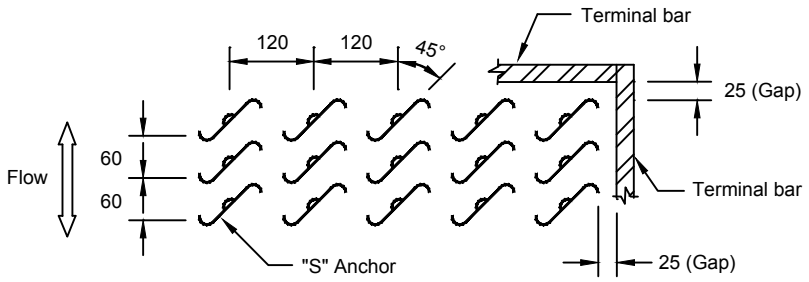
E ≡ Lining thickness ($E = E_1 + E_2$)

E_1 ≡ First thickness

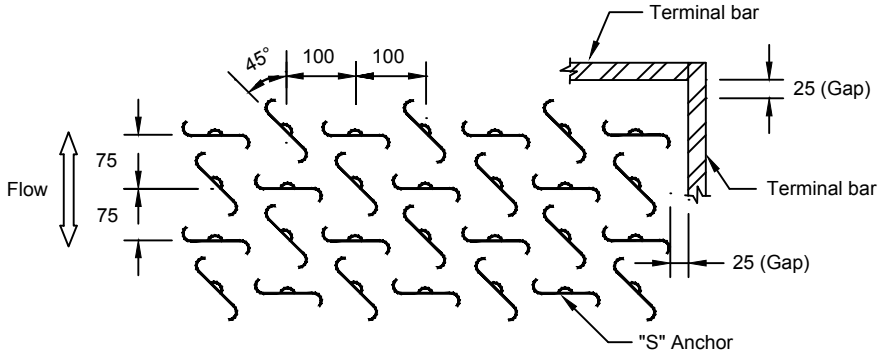
E_2 ≡ Second thickness

NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.13 - Installation of "V" and "Y" Anchors in Ceiling with Double Layer Lining



Detail A - For diameters up to 600 of inner lining

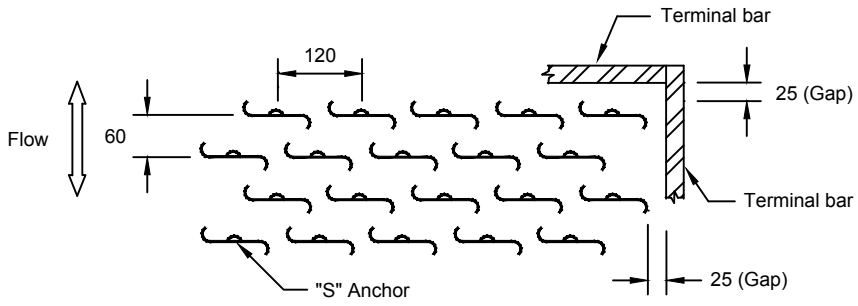


Detail B - For diameters from 600 to 900 of inner lining

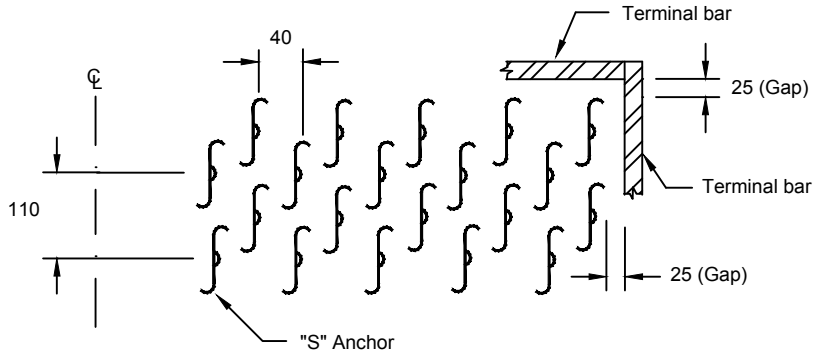
NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.14.1 - Details A and B

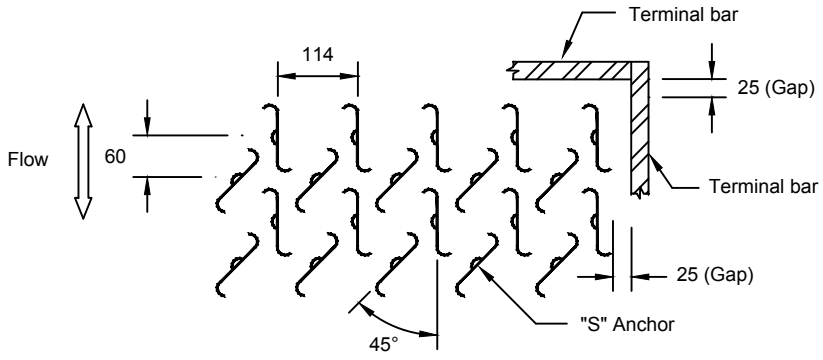
Figure A.14- Installation of "S" Anchor



Detail C - For diameters above 900 of inner lining



Detail D - For diameters up to 600 of outer lining

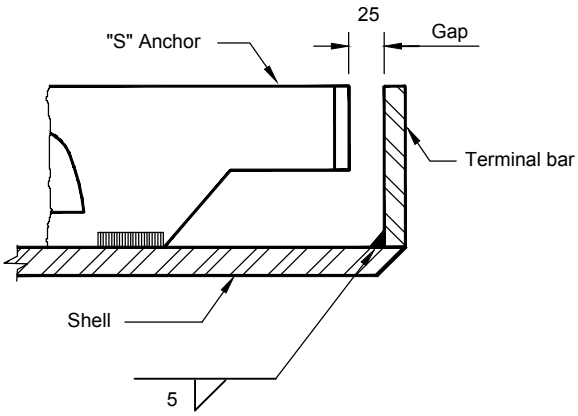


Detail E - For diameters above 600 of outer lining

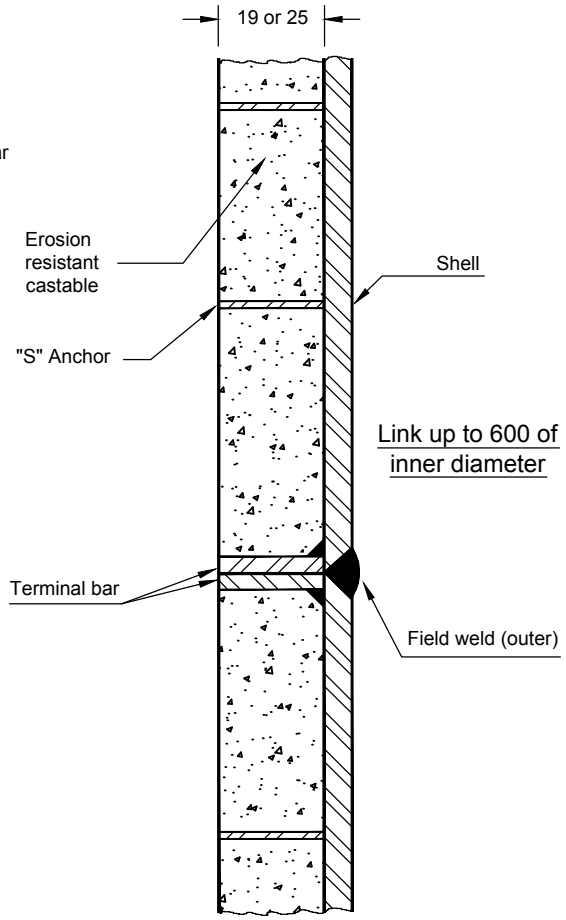
NOTE Dimensions in millimeters, except if otherwise indicated.

Figure A.14.2 - Details C, D and E

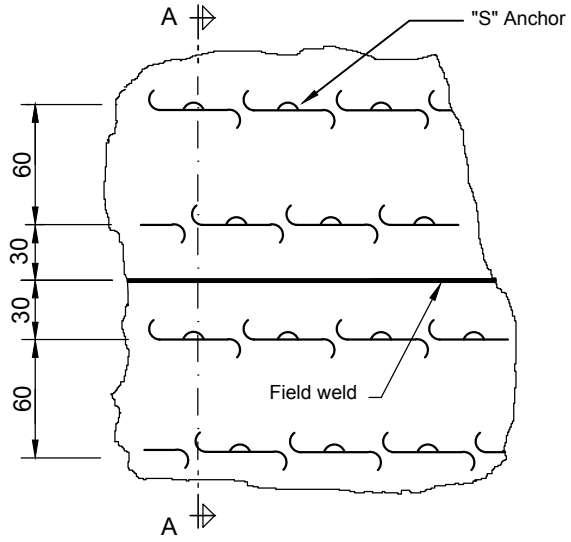
Figure A.14 - Installation of "S" Anchor



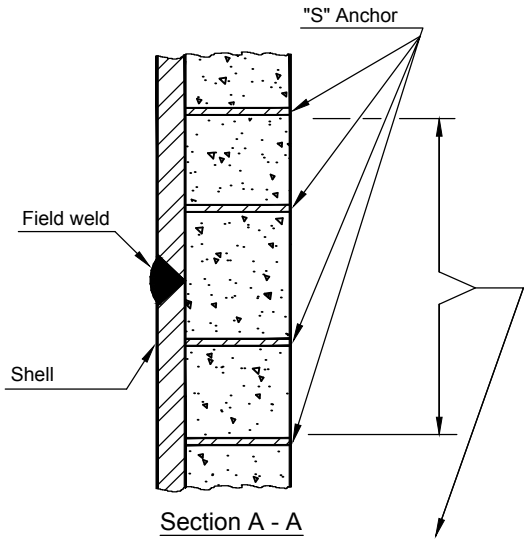
Installation of Terminal Bar



Link up to 600 of inner diameter



Link above 600 of inner diameter



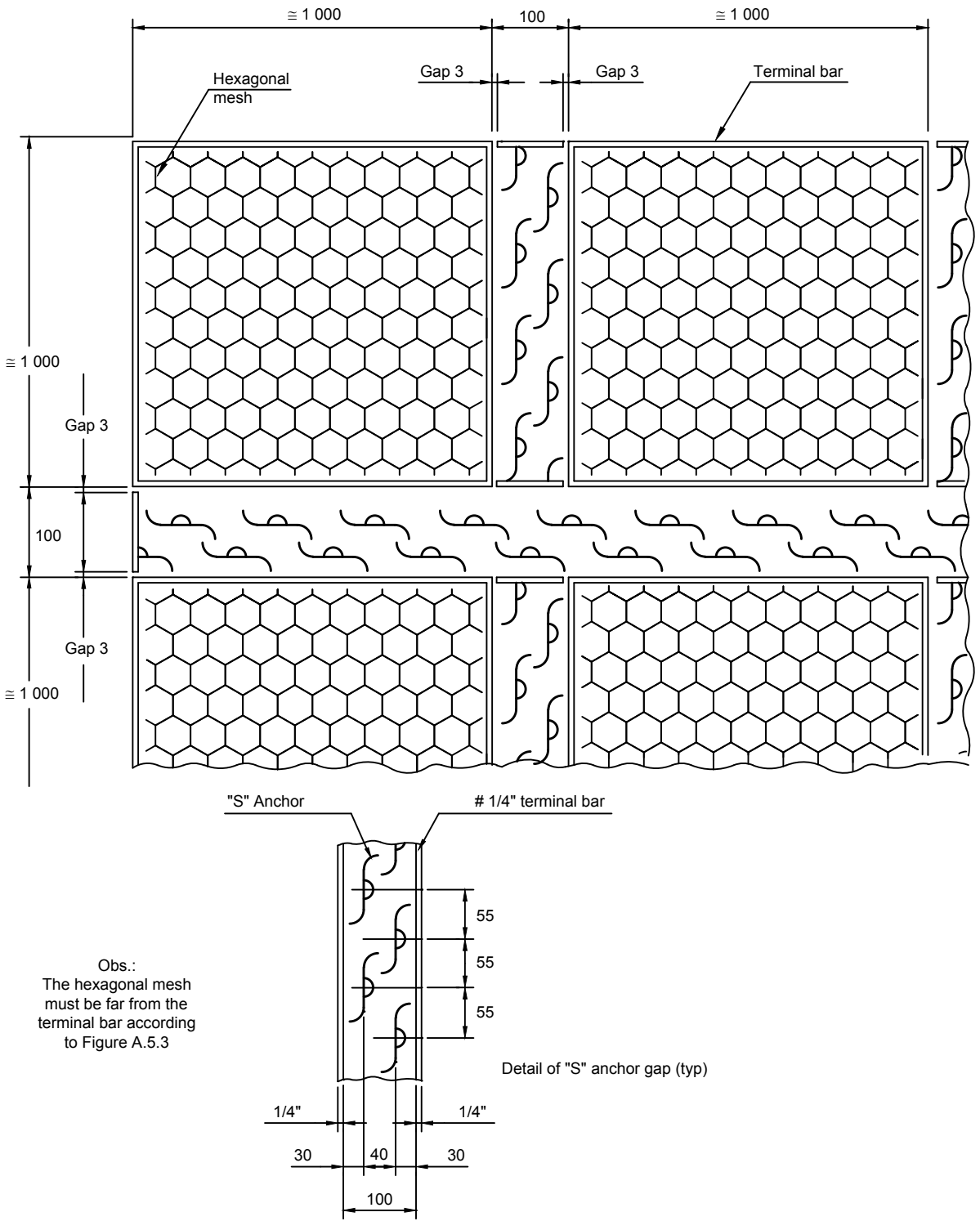
Section A - A

The refractory application in this region must be made in field

NOTE Dimensions in millimeters, except if otherwise indicated.

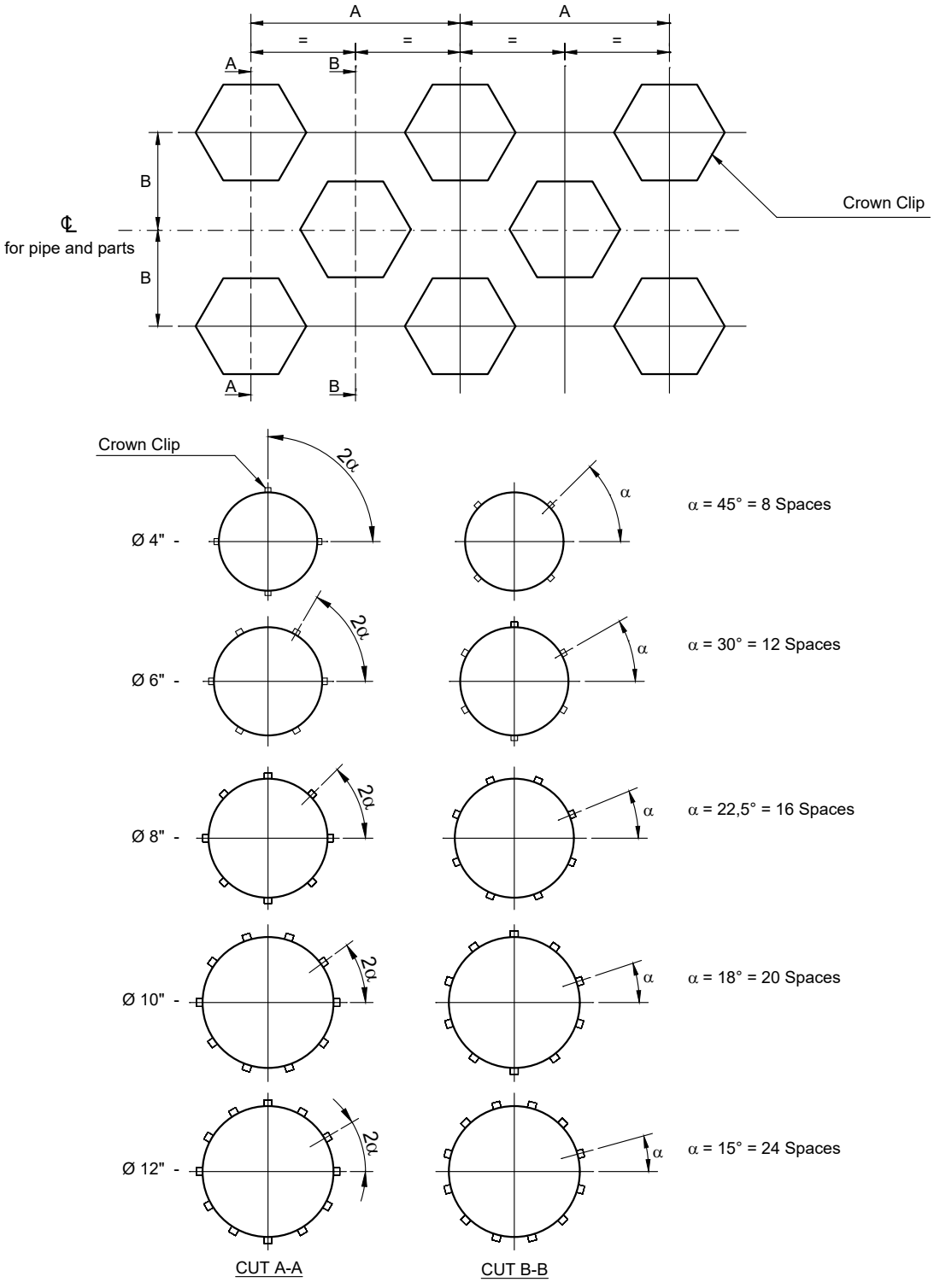
Figure A.14.3 - Details of Field Weld

Figura A.14 - Installation of "S" Anchor



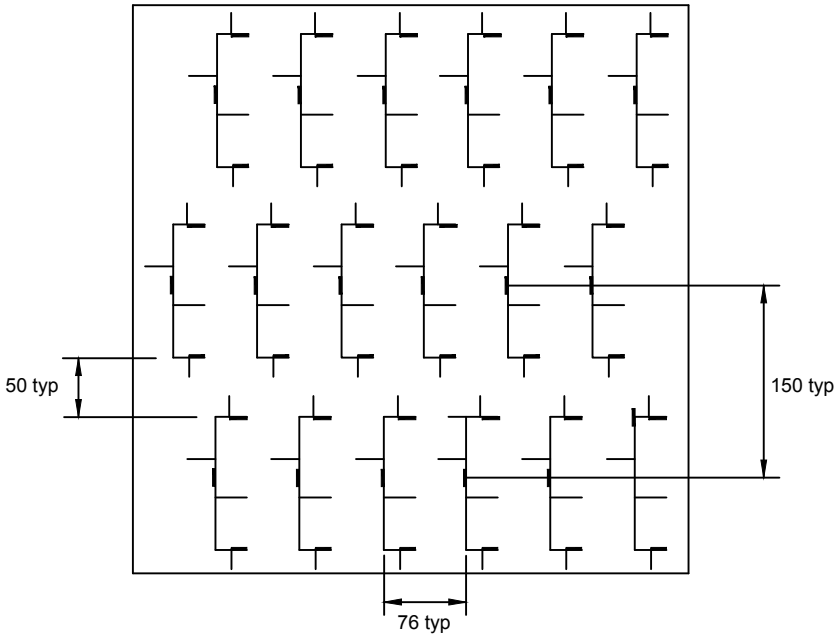
NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 Welding according to Figures A.5.3, A.14.1 and A.14.2.

Figure A.15 - Installation of Type II Mesh in Independent panels (Regions Subject to Coke Formation and Subject to Bloating)

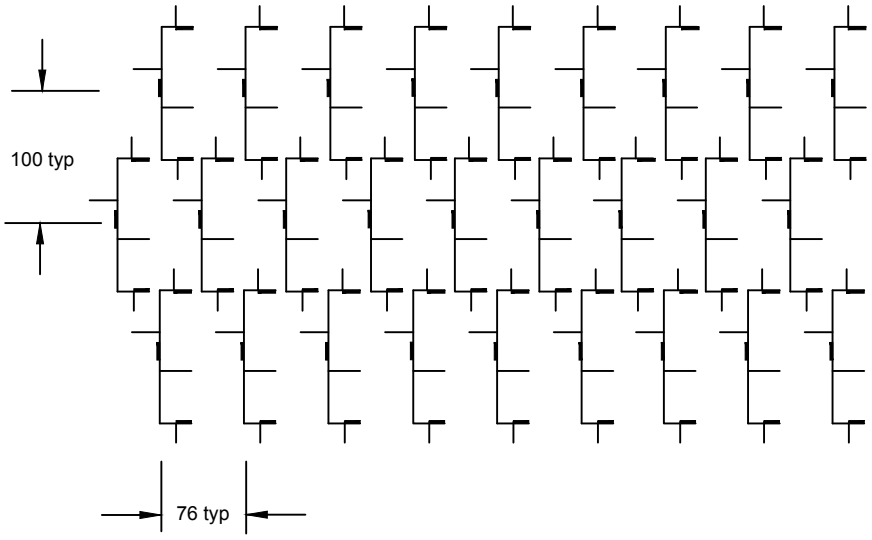


NOTE 1 Dimensions in millimeters, except if otherwise indicated.
NOTE 2 For outer piping lining from Ø 4" to Ø 8": A = $70^{\pm 3}$ and B = $44^{\pm 3}$.
NOTE 3 For outer piping lining from Ø 10" to Ø 12": A = $140^{\pm 3}$ and B = $43^{\pm 3}$.
NOTE 4 For inner and outer lining of flat surfaces and cylinder parts (internal or external) above Ø 12": A = $88^{\pm 3}$ and B = $70^{\pm 3}$.
NOTE 5 The "Crown Type Anchors" shall be welded at the three support points, on internal or external side of the anchor, with leg height of 3 mm.

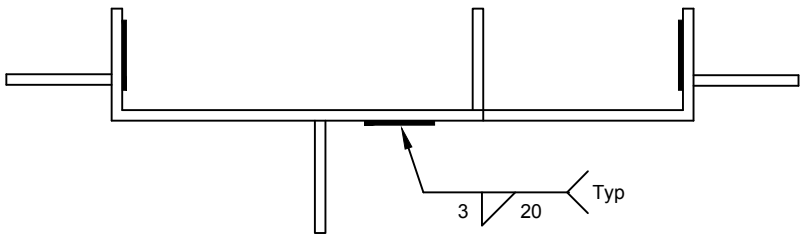
Figure A.16 - Installation of Crown Type Anchors



Anchoring Arrangments



Anchoring arrangments (region subject to formation of coke and/or vibration)

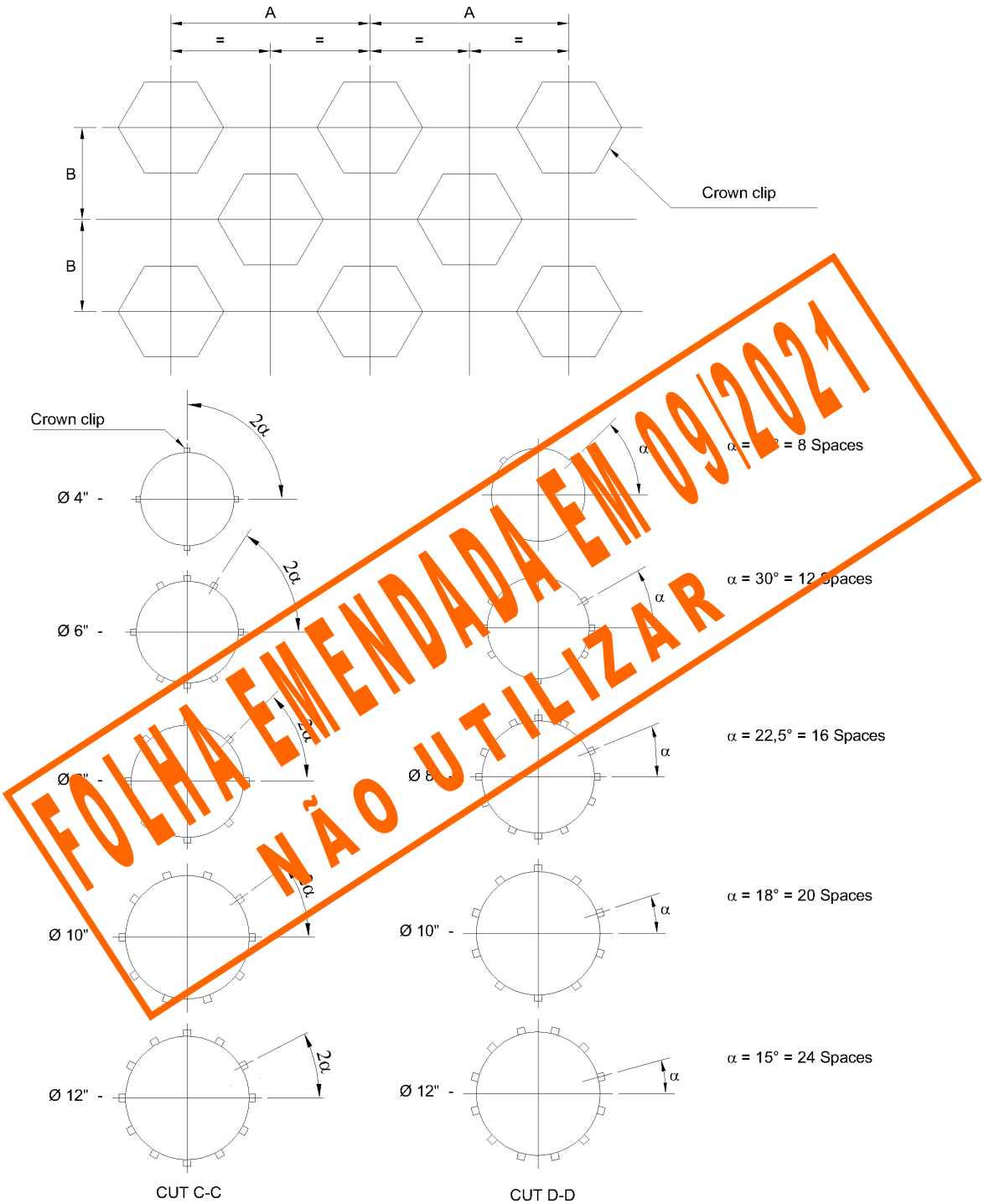


Detail of anchor welding

Dimensions in millimeters, except if otherwise indicated.

Figure A.17- Installation of "C" Anchor

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



NOTE 1 Dimensions in millimeters, unless otherwise specified.
NOTE 2 For external coating of pipes (∅ 4" a ∅ 12") A = $140^{\pm 3}$ B = $44^{\pm 3}$.
NOTE 3 For internal and external coating of tubes and cylindrical regions above ∅ 12" or plans A = $88^{\pm 3}$ B = $76^{\pm 3}$.
NOTE 4 The welding must be done on one side (internal or external) in contact area, with leg height of 3 mm.

Figure A.16 - Installation of Crown Type Anchors