

**N-1728****REV. L****ENGLISH****10 / 2015****CONTEC**Comissão de Normalização  
Técnica**SC-09**Thermal Insulation and  
Refractories**Castable Refractory**

Revalidation

Revalidated in 04/2022.

## Castable Refractory

### 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 nonmandatory 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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## 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.*

## Foreword

This Standard is the English version (issued in 09/2019) of PETROBRAS N-1728 REV. L 10/2015. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

## 1 Scope

1.1 This Standard establishes the conditions required for the acquisition of castable refractories and plastics as well as anchoring devices and complementary materials.

1.2 This Standard applies to design starting from its issue date as well as to existing equipment when it is repaired or remodeled.

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-1890](#) - Ceramic Fiber for Fired Heater Internal Linings;

ABNT [NBR 8385](#) - Materiais Refratários Não-Conformados - Determinação da Variação Linear Dimensional Permanentes;

ABNT [NBR 8826](#) - Materiais Refratários;

ABNT [NBR 10237](#) - Materiais Refratários - Classificação;

ABNT [NBR 11221](#) - Materiais Refratários Não-Conformados - Determinação da Densidades Aparente;

ABNT [NBR 11222](#) - Materiais Refratários Densos Não-Conformados - Determinação das Resistências à Flexão e à Compressão à Temperatura Ambiente;

ABNT [NBR 12856](#) - Fornecimento de Materiais Refratários;

ABNT [NBR 13185](#) - Materiais Refratários Densos - Determinação da Resistência à Erosão à Temperatura Ambiente;

ABNT [NBR 13320](#) – Materiais Refratários – Determinação da Fluides de Concretos Refratários Convencionais e Concretos de Fluência Livre;

ABNT [NBR 14725-4](#) - Produtos químicos - Informações sobre segurança, saúde e meio ambiente. Parte 4: Ficha de informações de segurança de produtos químicos (FISPQ);

ABNT [NBR ISO 8656-1](#) - Produtos Refratários - Amostragem de Matérias-Primas e Produtos Não Conformados - Parte 1: Esquema de Amostragem;

ABNT [NBR ISO 12677](#) - Análise Química de Produtos Refratários por Fluorescência de Raios X (XRF) - Método do Corpo de Prova Fundido;

API [STD 936](#) - Refractory Installation Quality Control-Inspection and Testing Monolithic Refractory Linings and Materials;

ASTM [A240/A240M](#) - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications;

ASTM [A479/A479M](#) - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels;

ASTM [A820/A820M](#) - Standard Specification for Steel Fibers for Fiber-Reinforced Concrete;

ASTM [C113](#) - Standard Test Method for Reheat Change of Refractory Brick;

ASTM [C133](#) - Standard Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories;

ASTM [C134](#) - Standard Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick;

ASTM [C201](#) - Standard Test Method for Thermal Conductivity of Refractories;

ASTM [C401](#) - Standard Classification of Alumina and Alumina-Silicate Castable Refractories;

ASTM [C704/C704M](#) - Standard Test Method for Abrasion Resistance of Refractory Materials at Room Temperature.

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

### 3 Terms and Definitions

For the purposes of this document, the terms and definitions given in ABNT [NBR 8826](#) and the following apply.

#### 3.1

##### **castable refractory**

compound made of one or more refractory aggregates of suitable grain sizes with a hydraulic or chemical setting binder

#### 3.2

##### **insulating castable refractory**

compound made of refractory cement and low density aggregates, resulting in a bulk density of 1 300 kg/m<sup>3</sup> or less after drying at 110 °C

#### 3.3

##### **semi-insulating castable refractory**

compound made of refractory cement with low and medium density aggregates, resulting in a bulk density higher than 1 300 kg/m<sup>3</sup> and lower than or equal to 1 700 kg/m<sup>3</sup> after drying at 110 °C

#### 3.4

##### **dense castable refractory**

compound made of refractory cement and high density aggregates, resulting in a bulk density higher than 1 700 kg/m<sup>3</sup> after drying at 110 °C

**3.5****plastic refractory**

moldable refractory material ready to be applied by accommodation and tamping for repair works or monolithic constructions

**3.6****castable refractory with metal fiber reinforcement**

product obtained by adding metal fibers to the castable refractory

**3.7****anchoring devices and complementary materials**

materials used for anchoring castables

**3.8****metallic fibers**

metallic fibers added to castables refractories in order to improve mechanical properties, preventing chipping and spalling losses

**4 General Conditions****4.1 Castable and Plastic Refractories**

4.1.1 Castable refractories shall have the properties mentioned in Table A.1 of Annex A.

NOTE In addition to the classes specified in Table A.1, castable refractories may also be classified according to ABNT [NBR 10237](#) or ASTM [C401](#)

4.1.2 Plastic refractories shall be classified as AL-70, AL-80 and AL-90, according to ABNT [NBR 10237](#).

**4.2 Anchoring Devices and Complementary Materials****4.2.1 Hexagonal and Flexmetal Meshes**

4.2.1.1 Hexagonal meshes are shown in Figures B.1 and B.2 of Annex B and shall be made from metal strips of the following materials: ASTM [A 240/ A 240M](#) type 304, 304L, 310, 316, 316L or 410S.

4.2.1.2 The flexmetal mesh is shown in Figure B.3 of Annex B and shall be made from metal strips of the following materials: ASTM [A 240/A 240M](#) type 304, 304L, 310, 316, 316L or 410S.

**4.2.2 Anchors and Studs**

4.2.2.1 The threaded stud is shown in Figure B.4 and the welded stud in Figure B.5 of Annex B and shall be made of the following materials: ASTM [A240/A240M](#) (plate) and ASTM [A479/A479M](#) (round bar), type 304, 304L, 310, 316, 316L or 410S.

4.2.2.2 The “V” and “wavy V” anchors are shown in Figures B.6 (B.6.1 and B.6.2) and B.8 (B.8.1 to B.8.3), the trident anchor in Figure B.9 and the “Y” anchor in Figure B.10 of Annex B and shall be made of the following materials:

- a) according to ASTM [A240/A240M](#) (plate) or ASTM [A479/A479M](#) (round bar) type 304, 304L, 310, 316, 316L, 330 or 410S;
- b) <sup>1)</sup>Inconel®.

**NOTE** Series 300 materials applied to regions subject to vibration shall be annealed after bending in accordance with ASTM [A479/A479M](#) where so specified.

4.2.2.3 The “S” anchor is shown in Figure B.11, the “L” anchor in Figure B.12 (B.12.1 and B.12.2), the hexcell anchor in Figure B.13, the “C” anchor in Figure B.14, split Y anchor in Figure B.15 and the “U” anchor in Figure B.16 of Annex B, and shall be made of the following materials: ASTM [A 240/A 240M](#) type 304, 304L, 310, 316, 316L or 410S.

4.2.2.4 The “Star” anchor shown in Figure B.17 of Annex B shall be made of the following materials: ASTM [A 479/A 479M](#) type 304, 304L, 310, 316, 316L or 410S.

### 4.2.3 Ceramic Anchors

Due to the diversity of applications, specific design is required for ceramic anchors, as those exemplified in Figure B.7 of Annex B. At least the following aspects shall be observed:

- a) the anchor shall be of shaped refractory, similar to the lining exposed to the medium (hot face), and supplied sintered;
- b) the chemical characteristics, physical and thermal properties, shape and dimensions must be specified according to the project;
- c) anchor height shall be equal to the total thickness of the lining; the geometry shall consider the lining application method to ensure no voids between the anchors and refractory; all corners and edges shall be rounded to avoid stress concentration;
- d) the metallic fixing devices for ceramic anchors shall be made of ASTM [A240/A240M](#) (plate) or ASTM [A 479/A479M](#) (round bar) type 304 or according to design.

### 4.2.4 End Bars

The end bars shall have a rectangular section, with 6 mm (1/4") thick and a width defined by the lining thickness, and shall be constructed according to ASTM [A240 / A240M](#), type 304, 304L, 310, 316, 316L or 410S.

### 4.2.5 Metal Fibers

4.2.5.1 Metal fibers shall be supplied in accordance with ASTM [A820/A820M](#) and the following requirements:

4.2.5.2 Metal fibers should be of the following types: **[Recommended Practice]**

- a) melt extracted;
- b) wire;
- c) flat.

<sup>1)</sup> Inconel® is a registered mark of property a metal alloy. This information is provided to help users in the use of this Standard and does not mean a recommendation of the mentioned product on the part of PETROBRAS. An equivalent product leading to the same results may be used.

4.2.5.3 Metal fibers shall be made of 304 type stainless steel.

4.2.5.4 The area of the straight section of the metal fiber shall be between 0,13 mm<sup>2</sup> and 0,28 mm<sup>2</sup>, which correspond to the effective diameter of 0,5 mm ± 0,1 mm.

4.2.5.5 The length of metal fibers shall be between 22 mm and 25 mm.

4.2.5.6 Wire and plate type metal fibers should be wavy or have other shapes. **[Recommended Practice]**

#### **4.2.6 Anticorrosion Mastic**

The specifications of the mastic shall comply with the criteria set out in PETROBRAS [N-1890](#).

### **4.3 Supply**

#### **4.3.1 Castable Refractories and Plastics**

4.3.1.1 Castable and plastic refractories must be supplied in accordance with ABNT [NBR 12856](#) and the following requirements:

4.3.1.2 The manufacturer must provide the Technical Data Sheet (TDS) including, at least, the following information:

- a) manufacturer's name;
- b) product commercial reference;
- c) description of the product (binder and main aggregates);
- d) material class according to Table A.1 of this Standard; **[Recommended Practice]**
- e) application methods;
- f) maximum temperature of use;
- g) chemical characteristics as below:
  - for the predominant oxides (Al<sub>2</sub>O<sub>3</sub> and SiO<sub>2</sub>) specify the lower and upper limits;
  - for the other oxides (CaO, P<sub>2</sub>O<sub>5</sub>, Fe<sub>2</sub>O<sub>3</sub>, alkalis etc.) specify the lower or upper limit, according to the specific case;
- h) physical properties, specifying at least the lower or upper limit, according with each property;

NOTE 1 Typical values are also recommended. **[Recommended Practice]**

NOTE 2 For gunning products, in addition to laboratory tests, it is recommended to present their limit values as applied by this method. **[Recommended Practice]**

- i) thermal properties, specifying typical values;
- j) water or other liquid agent (if applicable) percentage range;
- k) setting time;
- l) shelf life;
- m) packaging type(s) and net weight(s).

4.3.1.3 The manufacturer shall provide a production quality certificate for each lot supplied. This certificate must include at least:

- a) date of manufacture;
- b) production lot;
- c) sample preparation methods;

- d) water or other liquid agent (if applicable) percentage range;
- e) chemical analysis; [Recommended Practice]
- f) bulk density (dried at 110 °C);
- g) cold crushing strength (dried at 110 °C and fired at 815 °C);
- h) permanent linear change (PLC from dried at 110 °C to fired at 815 °C);
- i) erosion resistance (dried at 110 °C and fired at 815 °C, only for erosion resistant materials);
- j) fluidity (only for self-flow castables) in accordance with ABNT [NBR 13320](#);
- k) setting time;

**NOTE** Sampling for the determination of the parameters mentioned in e), f), g), h) and i) shall be in accordance with ISO [8656-1](#) or manufacturer sampling plan.

4.3.1.4 Packages, including for bi-component materials, shall be identified with at least the following information:

- a) manufacturer's name;
- b) product commercial reference;
- c) production lot;
- d) date of manufacture;
- e) shelf life;
- f) nominal net weight.

4.3.1.5 The packages may be identified according to the models available in Annex D. **[Recommended Practice]**

4.3.1.6 The manufacturer shall provide an Installation Data Sheet (IDS) for materials including, at least, the following information:

- a) water or other liquid agent (if applicable) percentage range;
- b) mixing method (if applicable);
- c) mixing temperature range (if applicable);
- d) pre-mixing time and water or other liquid agent (if applicable) percentage range;
- e) mixing time (dry and wet) (if applicable);
- f) type of equipment required for mixing and installation (mixer, gunning machine, vibrators etc.) (if applicable);
- g) installation method;
- h) setting time;
- i) curing procedure (if applicable);
- j) dryout requirements: air drying time; dryout schedule, with heating rates, hold durations and others.

4.3.1.7 The manufacturer shall provide the Material Safety Data Sheet (MSDS) in accordance with ABNT NBR [14725-4](#).

4.3.1.8 Its recommended that the supply of refractor castables with metallic fibers been supplied with separately fibers **[Recommended Practice]**

#### **4.3.2 Anchoring Devices and Complementary Materials**

4.3.2.1 The hexmesh should be supplied in 2 m x 1 m panels. Strip direction (length or width) shall be as indicated on purchase document. It can be packed on pallets held tight by means of metal strips or wood. **[Recommended Practice]**



4.3.2.2 Metal fibers can be packed in drums, cardboard boxes or small wooden boxes provided the net mass does not exceed 25 kg. **[Recommended Practice]**

4.3.2.3 The manufacturer shall provide the quality certificate for anchoring devices and complementary materials, including at least the chemical analysis of the materials.

## 5 Material Receiving (Acceptance Inspection)

### 5.1 Castable Refractories and Plastics

5.1.1 The verification of the parameters, listed in Table A.1, should follow the following procedure:

- a) analyze the production quality certificate issued by the manufacturer, comparing the results with the TDS (or Compliance Data Sheet) and Table A.1. In case of divergence, the manufacturer should be requested for PETROBRAS evaluation, before testing the lot received;
- b) sample and test the lot received in accordance with Annex C. The results shall be in accordance with the PDS and Table A.1.

**NOTE** If the PDS does not present the acceptance limits for each physical property, presenting only typical values, then the tolerances described in Table 1 must be applied.

**Table 1 - Minimum and Maximum Tolerances for Typical Values**

Physical Properties	Tolerances	
	Minimum	Maximum
Erosion Loss	N/A	+10 %
Cold crushing strength	-10 %	N/A
Bulk density	-80 kg/m <sup>3</sup>	+80 kg/m <sup>3</sup>
Permanent linear change	Zero	+10 %

Based on Table 3 of API STD 936.

5.1.2 For refractory plastics the acceptance criterion shall be the TDS of the manufacturer.

**NOTE** When castable refractory and plastic are received at the manufacturer's facilities, the sampling plan can be adopted since it has been previously agreed upon. **[Recommended Practice]**

### 5.2 Inspection of Anchoring Devices and Complementary Materials

5.2.1 Receiving inspection, such as: visual, dimensional, material and other compliance verification with the purchase request.

5.2.2 Verify the production quality certificate, issued by the manufacturer, comparing the results with this Standard.

**Annex A - Table****Table A.1 - Castable Refractory**

Characteristics	Dense						Semi Insulating	Insulating			Unit	Standards
	Erosion Resistant			Regular		High Alumina		Class A	Class B	Class C		
	Class A	Class B	Class C	Class A	Class B							
<b>Chemical Analysis:</b> (Note 9) - Al <sub>2</sub> O <sub>3</sub> (minimum);	80,0	80,0	40,0	70,0	40,0	94,0 (Note 10)	35,0	30,0	30,0	30,0	%	ABNT NBR ISO 12677
- SiO <sub>2</sub> (maximum);	8,0	(Note 3)	50,0	15,0	50,0	-	55,0	50,0	45,0	40,0		
- CaO (maximum);	5,0	8,0	12,0	10,0	7,0	4,0	12,0	12,0	15,0	20,0		
- Fe <sub>2</sub> O <sub>3</sub> (maximum)	1,0	1,0	1,5	1,5	3,0	0,4	3,0	8,0	10,0	10,0		
<b>Maximum Service Temperature</b>	1 200	1 200	1 200	1 600	1 400	1700	1 300	1 100	1 100	900	°C	Linear dimensional change of 1,5 % (Note 6)
<b>Bulk Density:</b> - dried at 110 °C	≥ 2 500	≥ 2 500	≤ 2 600	≥ 2 300	≤ 2 300	≥ 2 600	≤ 1 750	≤ 1 300	≤ 1 000	≤ 850	kg/m³	ABNT NBR 11221 ASTM C134
<b>Minimum Cold Crushing Strength</b>  - dried at 110 °C;	50,0 (510)	45,0 (459)	35,0 (357)	40,0 (408)	20,0 (204)	30,0 (306)	6,9 (70)	5,4 (55)	2,4 (25)	0,7 (7)	MPa (kgf/cm²)	ABNT NBR 11222 ASTM C133
- fired at 815 °C.	75,0 (765)	40,0 (408)	30,0 (306)	35,0 (357)	12,0 (122)	40,0 (408)	4,4 (45)	2,9 (30)	1,2 (12)	0,3 (3)		
<b>Maximum Permanent Linear Change:</b> <b>(Note 11)</b> - fired at 815 °C.	- 0,50	- 0,50	- 0,50	- 0,50	- 0,50	- 0,30	- 0,50	- 0,50	- 1,20	- 1,50	%	ABNT NBR 8385 ASTM C113
<b>Thermal Conductivity at Average Temperature of</b> - 200 °C;	-	-	1,29 (1,11)	-	-	-	0,45 (0,39)	0,38 (0,33)	0,26 (0,22)	0,17 (0,15)	W/m.K	ASTM C201
- 400 °C;	-	-	1,27 (1,09)	-	-	-	0,47 (0,41)	0,42 (0,36)	0,29 (0,25)	0,20 (0,17)	(kcal/ m.h.°C)	
- 600 °C.	-	-	1,24 (1,07)	-	-	-	0,50 (0,43)	0,45 (0,39)	0,33 (0,28)	0,22 (0,19)		
<b>Maximum Abrasion Loss:</b>  - fired at 815 °C	3,5	12,0	12,0 (Note 4) 20,0 (Note 5)	-	-	-	-	-	-	-	cm³	ABNT NBR 13185 ASTM C704

NOTE 1 In the case of Class B or C erosion resistant, indicate whether or not it is a low cement castable.

NOTE 2 Class A erosion resistant castable shall be chemical bonding or formulated to not require water spray or other curing element.

NOTE 3 For conventional concrete 0,5 % shall be specified and for low cement castables, 9,0 %.

NOTE 4 For low cement content materials applied by external vibration and free flow materials.

NOTE 5 For materials applied by conventional pouring or pneumatic gunning.

NOTE 6 Maximum temperature of use: consider the temperature for linear dimensional variation of 1.5% after burning for 5 hours. Criteria for maximum temperature of use according to ASTM C401;

NOTE 7 For concretes applied by free flowing, they must have fluidity greater than 75% after 20 min of the mixture;

NOTE 8 Antacid concrete must meet the properties (mandatory) of each class in Table A.1;

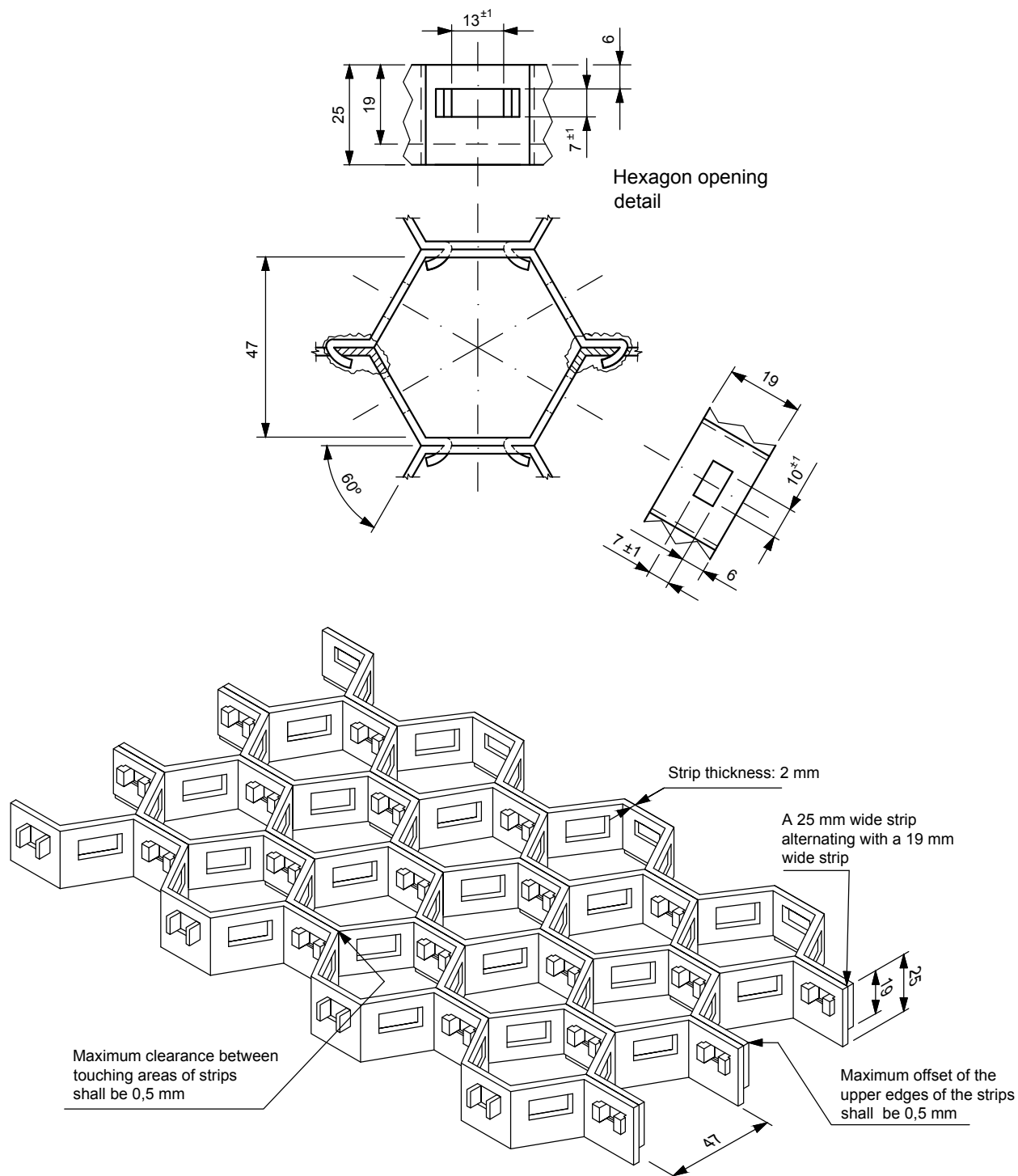
NOTE 9 Reference value, but not selective;

NOTE 10 Selective value, meet minimum specification;

NOTE 11 Linear dimensional variation greater than zero is not permissible;

NOTE 12 For chemical bonded concrete lower values for compressive strength at 110 ° C are allowed provided the result at 815 ° is framed.

## Annex B - Figures

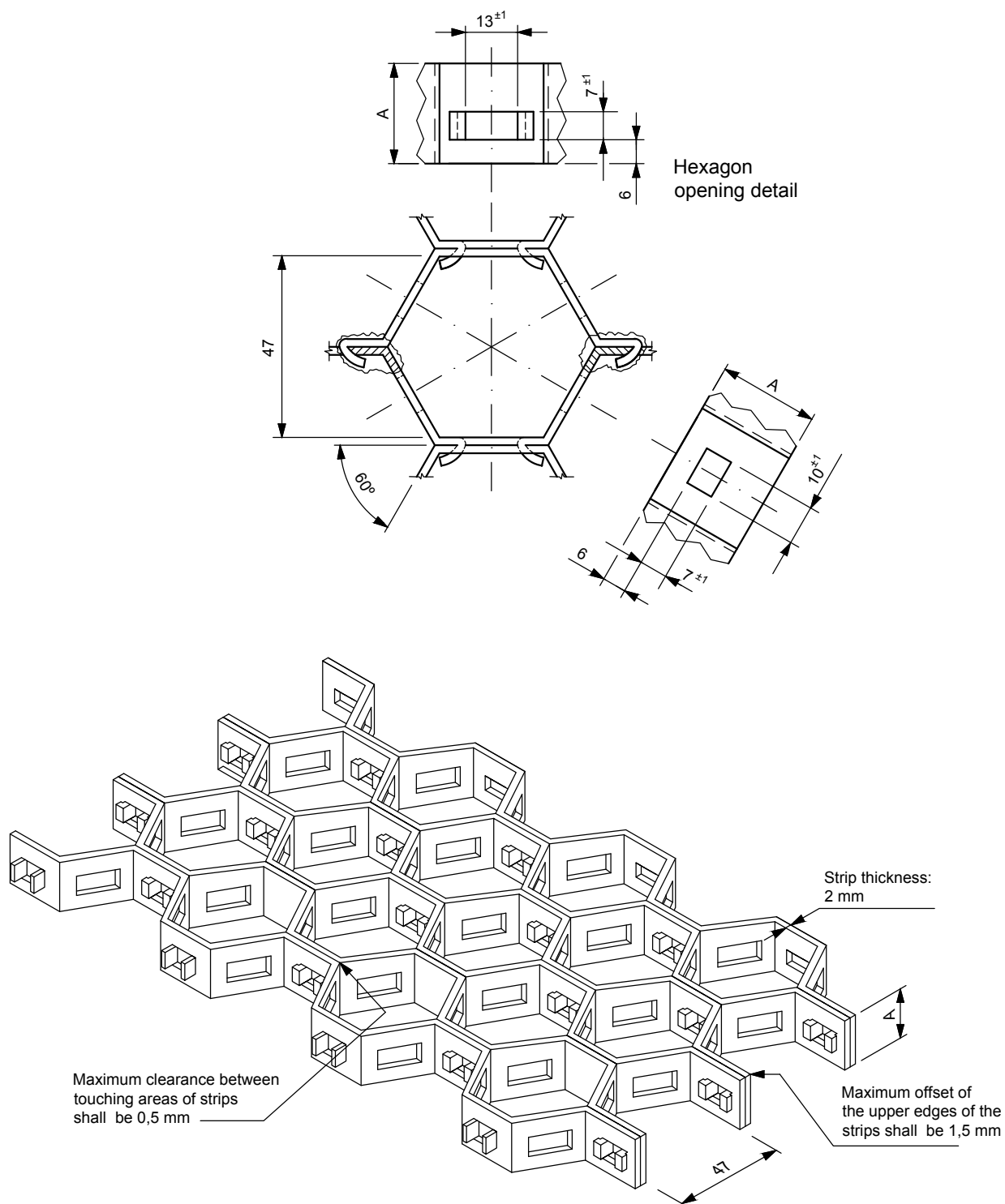


NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 In cases where the hexmesh is made of ASTM A240 type 410S steel, adjacent hexagons may be joined by means of separate clip.

Figure B.1 - Hexmesh Type I



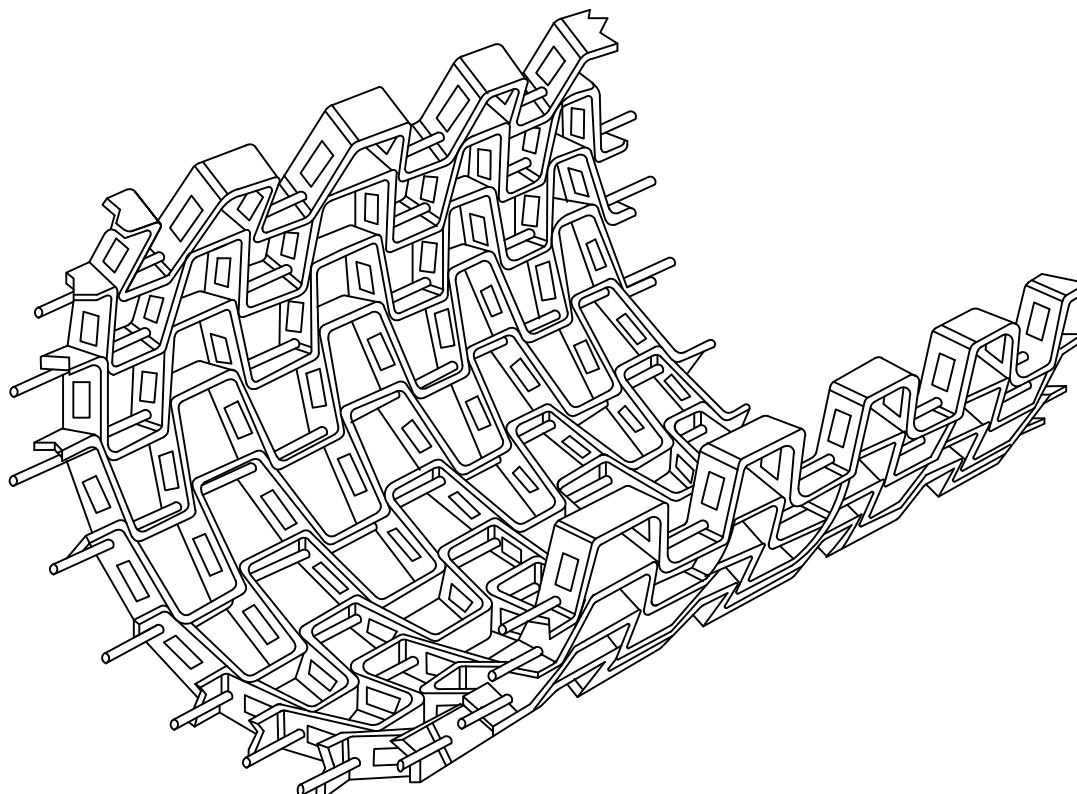
NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

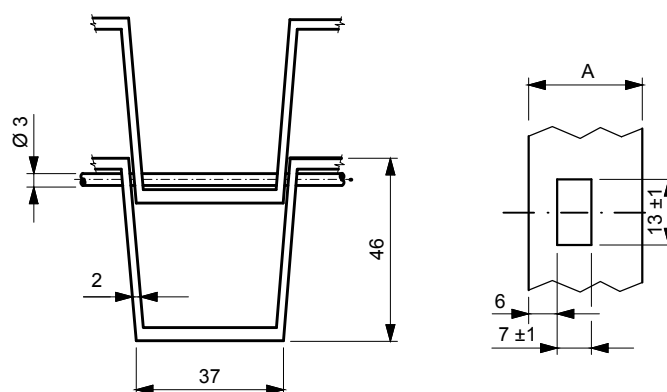
NOTE 3 A=19 or 25 mm.

NOTE 4 In cases where the hexmesh is made of ASTM A240 type 410S steel, adjacent hexagons may be joined by means of separate clip.

Figure B.2 - Hexmesh Type II



Drilling detail



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

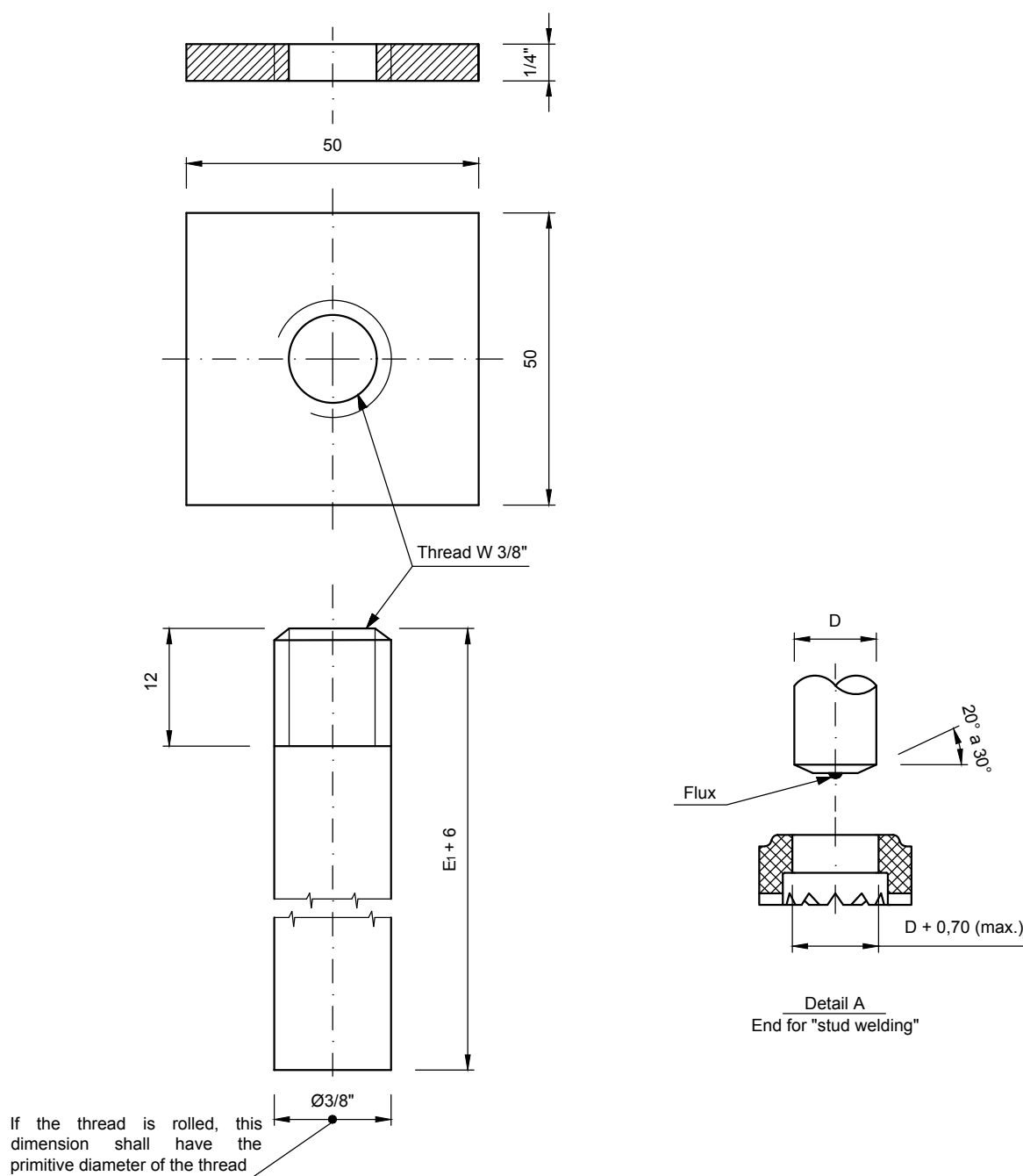
NOTE 3 Strip thickness of 2 mm.

NOTE 4 Wire ends shall be bent to a length around 15 mm.

NOTE 5 Drilling in the longitudinal strips is allowed as required in the manufacturing process.

NOTE 6 A = 19 ou 25 mm.

Figure B.3 - Flexmetal Mesh



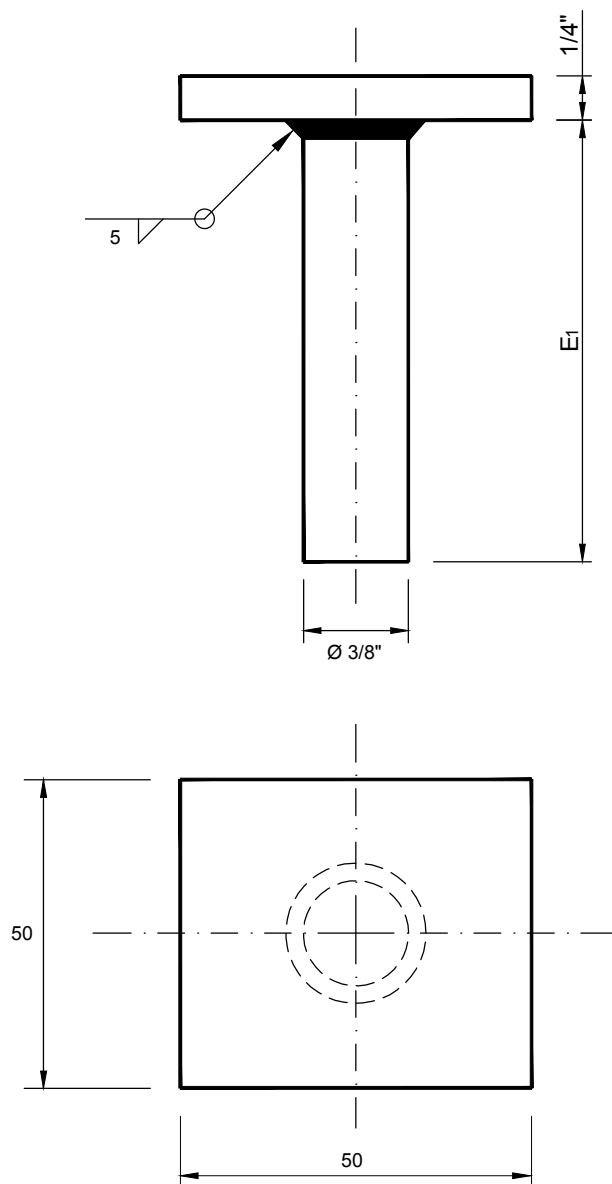
NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3  $E_1$  = thickness of inner layer of lining.

NOTE 4 The ceramic for the stud welding process shall be supplied with the stud (when applicable).

Figure B.4 - Threaded Stud



NOTE 1  $E_1$  = thickness of inner layer of lining.

NOTE 2 Dimensions in millimeters, unless otherwise indicated.

NOTE 3 Overall tolerance:  $\pm 5 \%$

**Figure B.5 - Welded Stud**

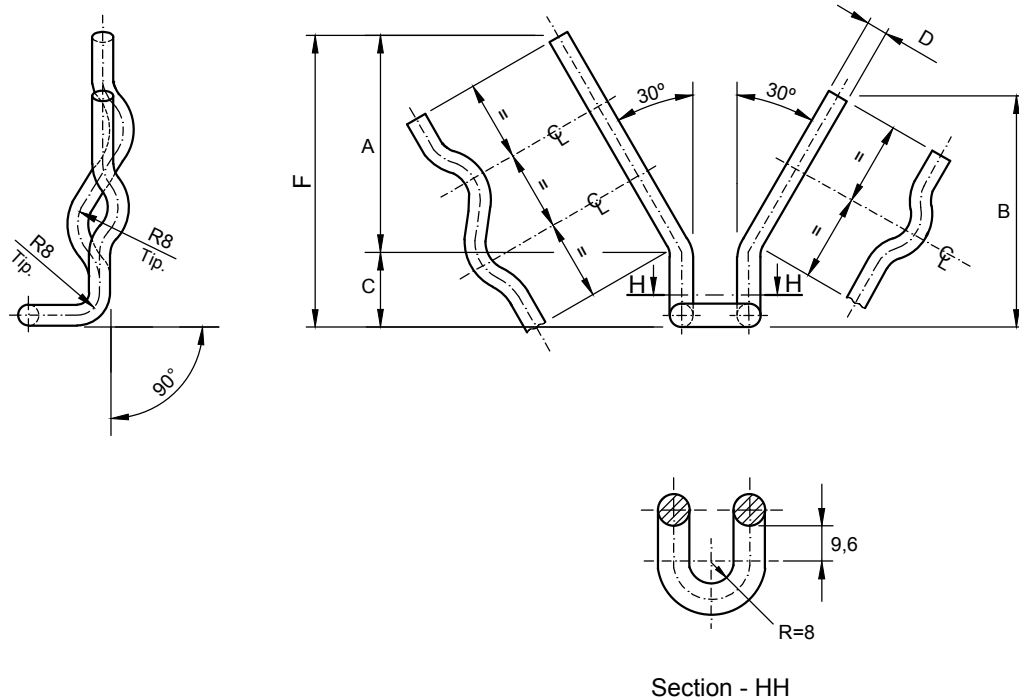


Table - Anchor Dimensions

E	D	A	B	C	F
75	1/4"	62	49	0	A+C
100	5/16"	70	70	13	A+C
125	5/16"	79	91	25	A+C
150	5/16"	100	112	25	A+C
>150	5/16"	4/5E-25	2/3E	25	A+C

NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 E = total thickness of lining.

NOTE 4 The lower leg has a wave. The larger leg has two waves, except for the refractory thickness E = 75 mm which must be done with just a wave.

**Figure B.6.1 - Wavy "V" Anchor - Type I**

**Figure B.6 - "V" Anchors**



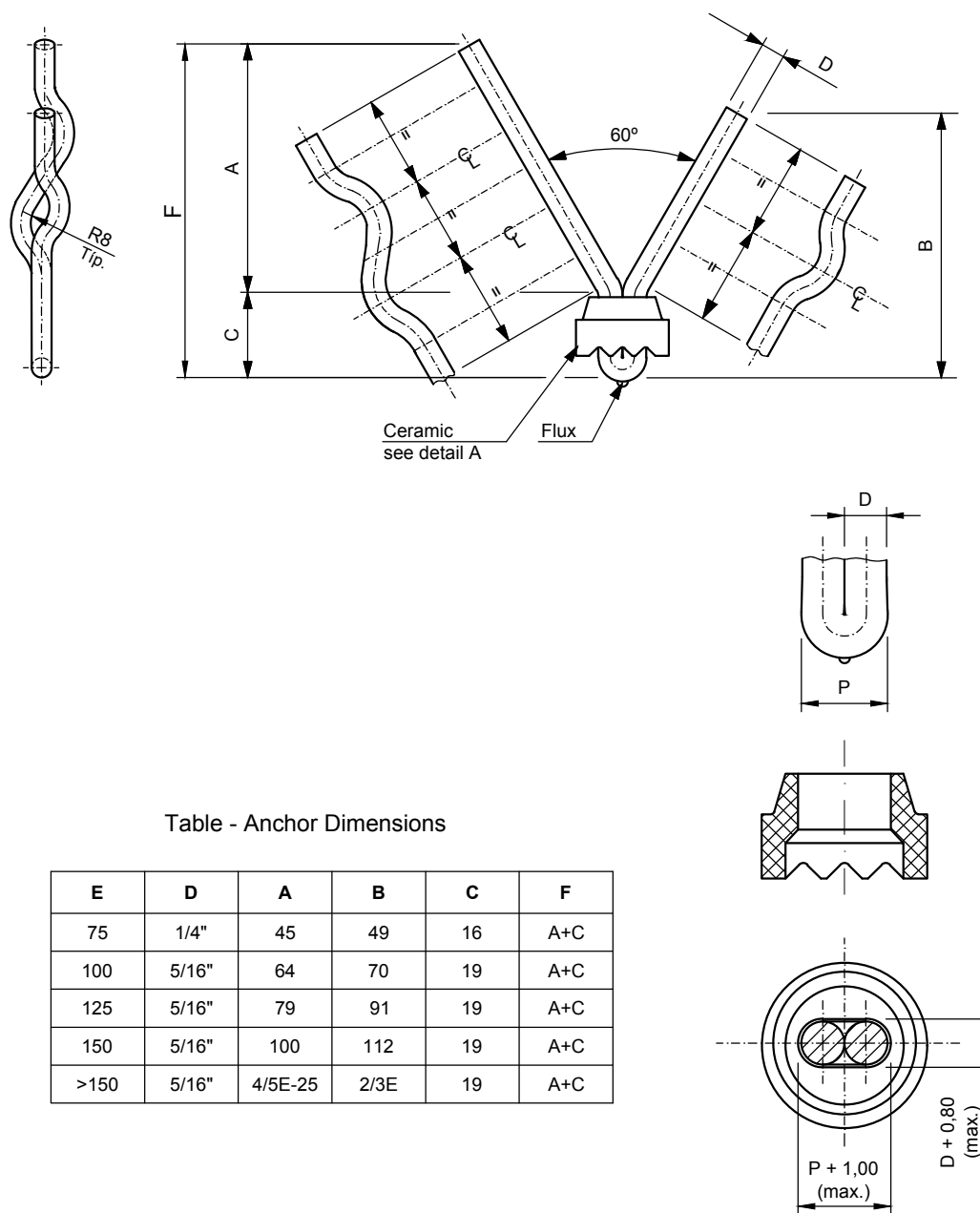


Table - Anchor Dimensions

E	D	A	B	C	F
75	1/4"	45	49	16	A+C
100	5/16"	64	70	19	A+C
125	5/16"	79	91	19	A+C
150	5/16"	100	112	19	A+C
>150	5/16"	4/5E-25	2/3E	19	A+C

Detail A  
End to "Stud Welding"

NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 E = total thickness of lining.

NOTE 4 The lower leg has a wave. The larger leg has two waves, except for the refractory thickness E = 75 mm which must be done with just a wave.

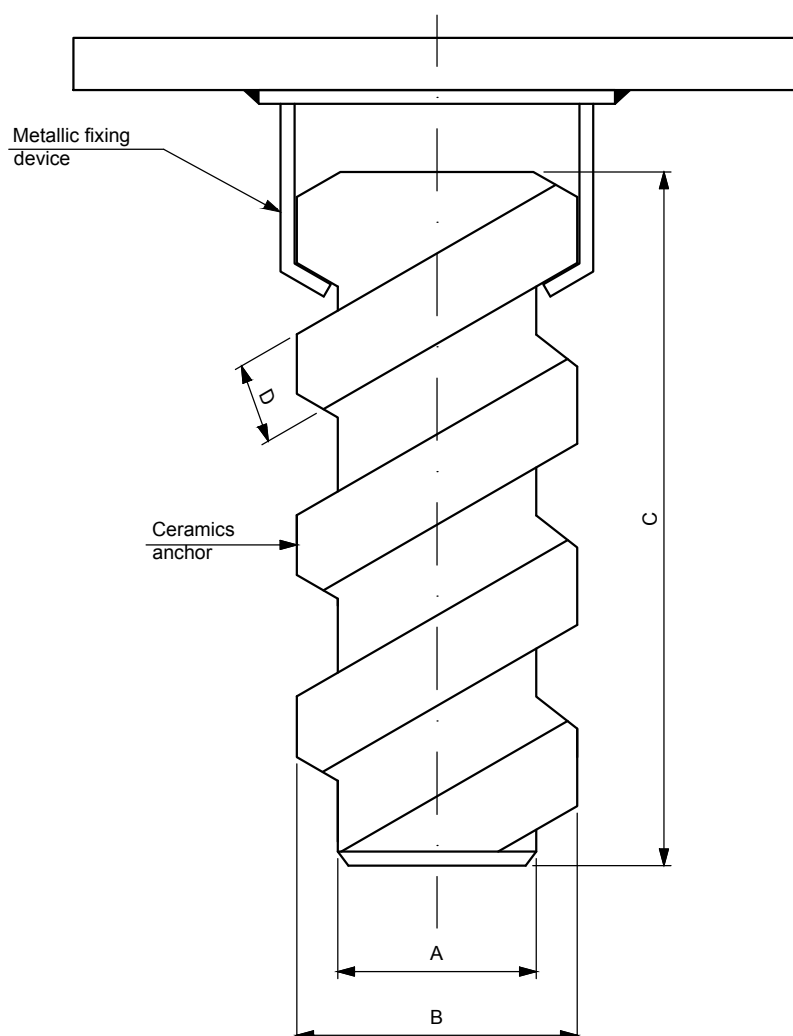
NOTE 5 Maximum hardness of wire before conformation: 170 HB.

NOTE 6 The anchors shall have solid flux for welding on their bases.

NOTE 7 The ceramic for the "Stud Welding" process shall be supplied with the anchor.

Figure B.6.2 - Wavy "V" Anchor - Type II

Figure B.6 - "V" Anchors (continuation)



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 Dimensions: A, B, C and D, according to the project.

Figure B.7 - "Ceramic Anchors"

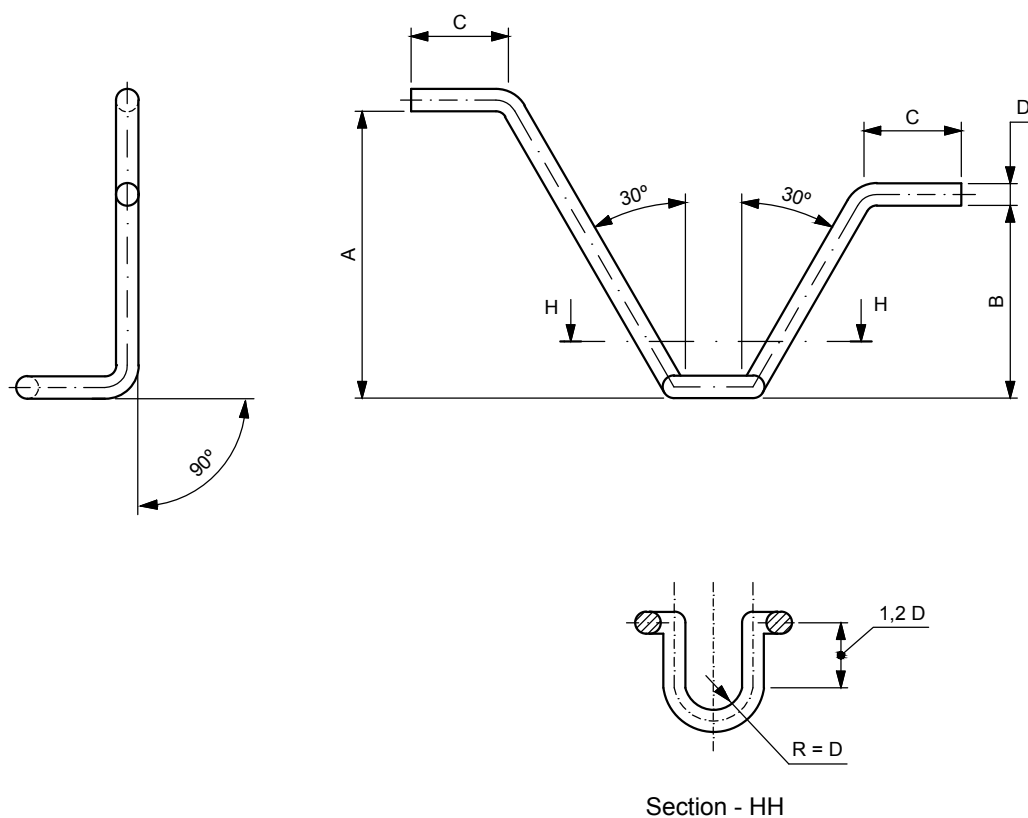


Table - Anchor Dimensions

E	D	A	B	C
50	3/16"	33	25	15
63	3/16"	42	32	15
75	3/16"	50	38	15
90	1/4"	60	45	20
100	1/4"	66	50	20
113	1/4"	75	57	20
125	5/16"	83	63	20
150	5/16"	100	75	20
>150	5/16"	2/3E	1/2E	20

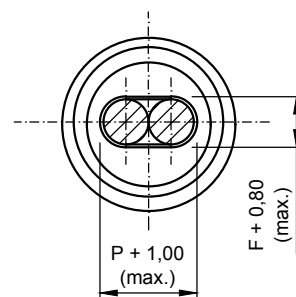
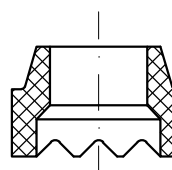
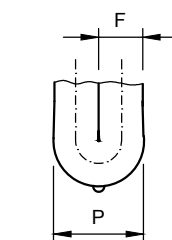
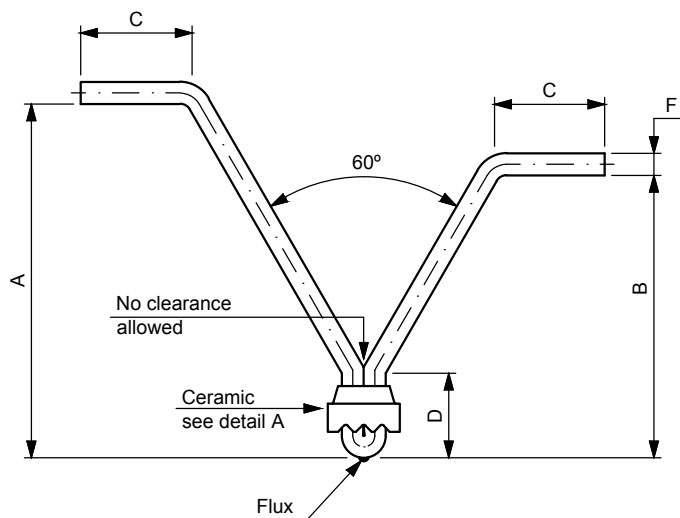
NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 E = total thickness of lining.

Figure B.8.1 - "V" Anchor - Type I

Figure B.8 - "V" Anchors



**Detail A**  
End to "Stud Welding"

**Table - Anchor Dimensions**

E	F	A	B	C	D
50	3/16"	33	25	15	16
63	3/16"	42	32	15	16
75	3/16"	50	38	15	16
90	1/4"	60	45	20	19
100	1/4"	66	50	20	19
113	1/4"	75	57	20	19
125	5/16"	83	63	20	19
150	5/16"	100	75	20	19
>150	5/16"	2/3E	1/2E	20	19

NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 Supply includes the ceramics.

NOTE 4 The anchors shall have solid flux for welding on their bases.

NOTE 5 E = total thickness of lining.

NOTE 6 The ceramic for the "Stud Welding" process shall be supplied with the anchor.

**Figure B.8.2 - "V" Anchor - Type II**

**Figure B.8 - "V" Anchors (Continuation)**

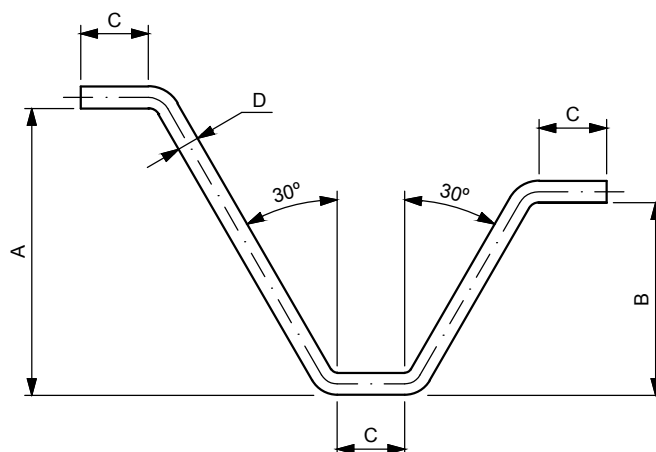


Table - Anchor Dimensions

E	D	A	B	C
50	3/16"	33	25	15
63	3/16"	42	32	15
75	3/16"	50	38	15
90	1/4"	60	45	20
100	1/4"	66	50	20
113	1/4"	75	57	20
125	5/16"	83	63	20
150	5/16"	100	75	20
>150	5/16"	2/3E	1/2E	20

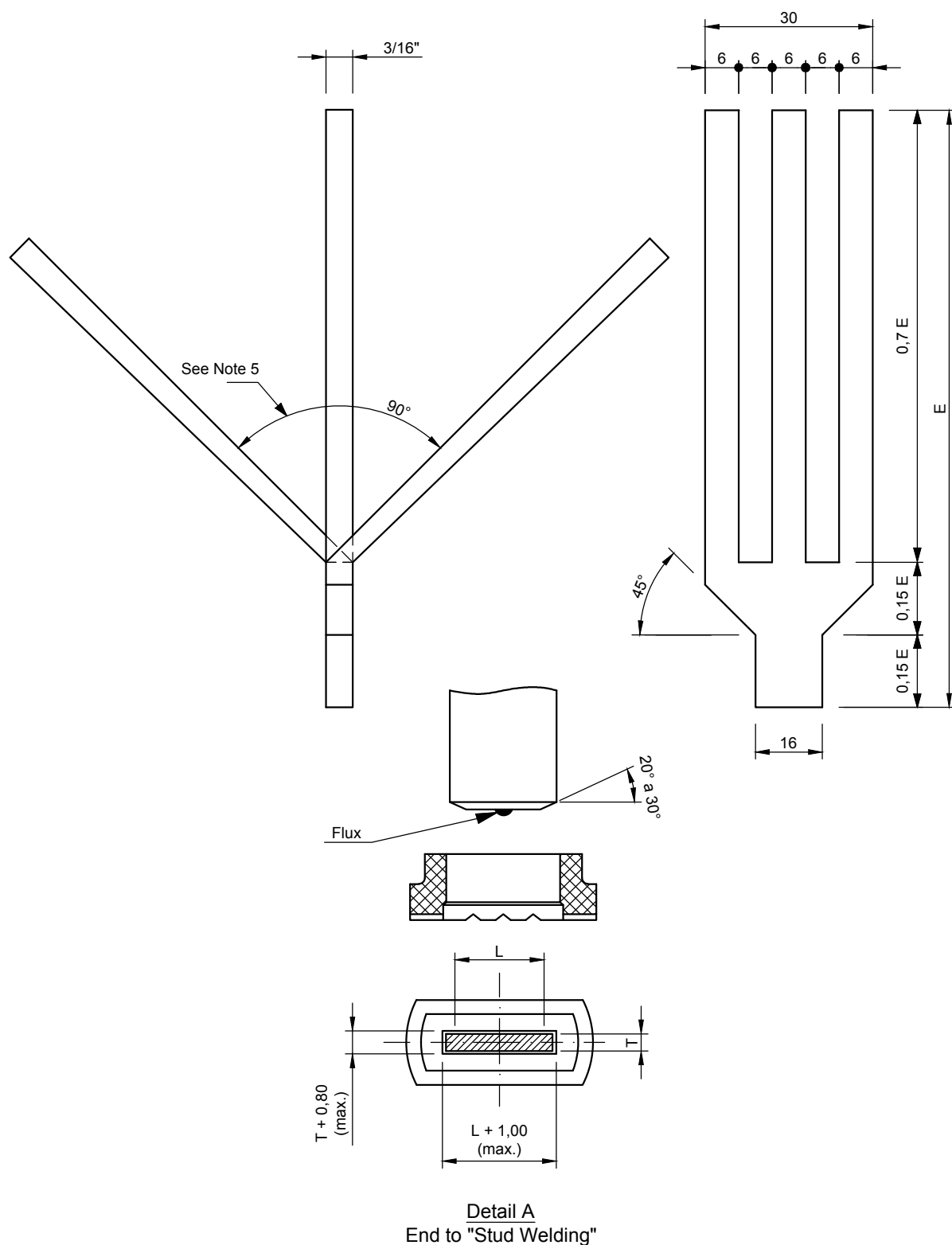
NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 E = total thickness of lining.

Figure B.8.3 - "V" Anchor - Type III

Figure B.8 - "V" Anchors (Continuation)



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

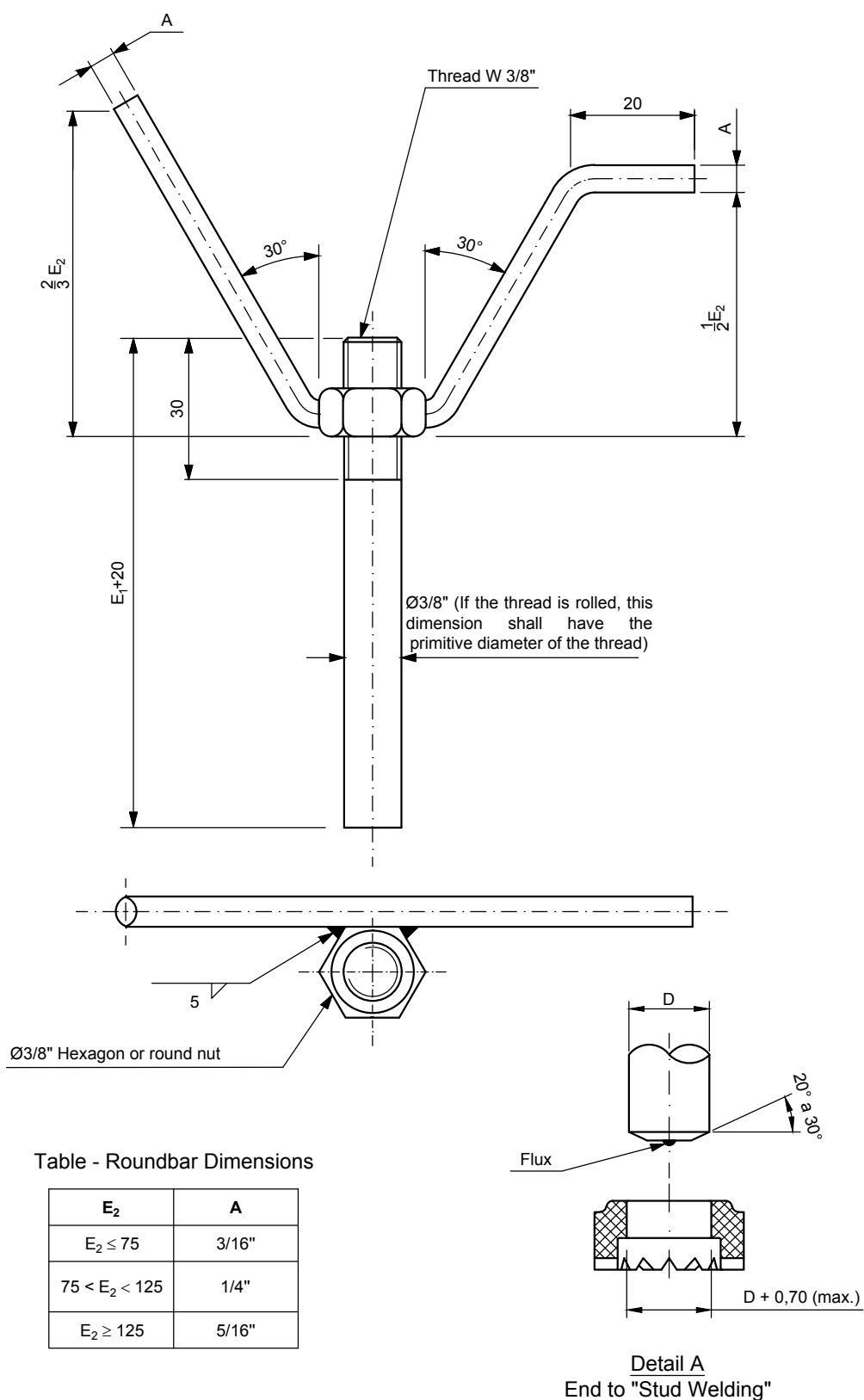
NOTE 3 E = Total thickness of lining.

NOTE 4 No burrs.

NOTE 5 Folding after welding.

NOTE 6 The ceramic for the stud welding process shall be supplied with the anchor (when applicable).

**Figure B.9 - Trident Anchor**



- NOTE 1 Dimensions in millimeters, unless otherwise indicated.  
 NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.  
 NOTE 3 The ceramic for stud welding process shall be supplied with the anchor (when applicable).  
 NOTE 4 E = Total thickness of lining ( $E = E_1 + E_2$ ).  
 NOTE 5  $E_1$  = Thickness of inner layer.  
 NOTE 6  $E_2$  = Thickness of external layer.

**Figure B.10 - "Y" Anchor**

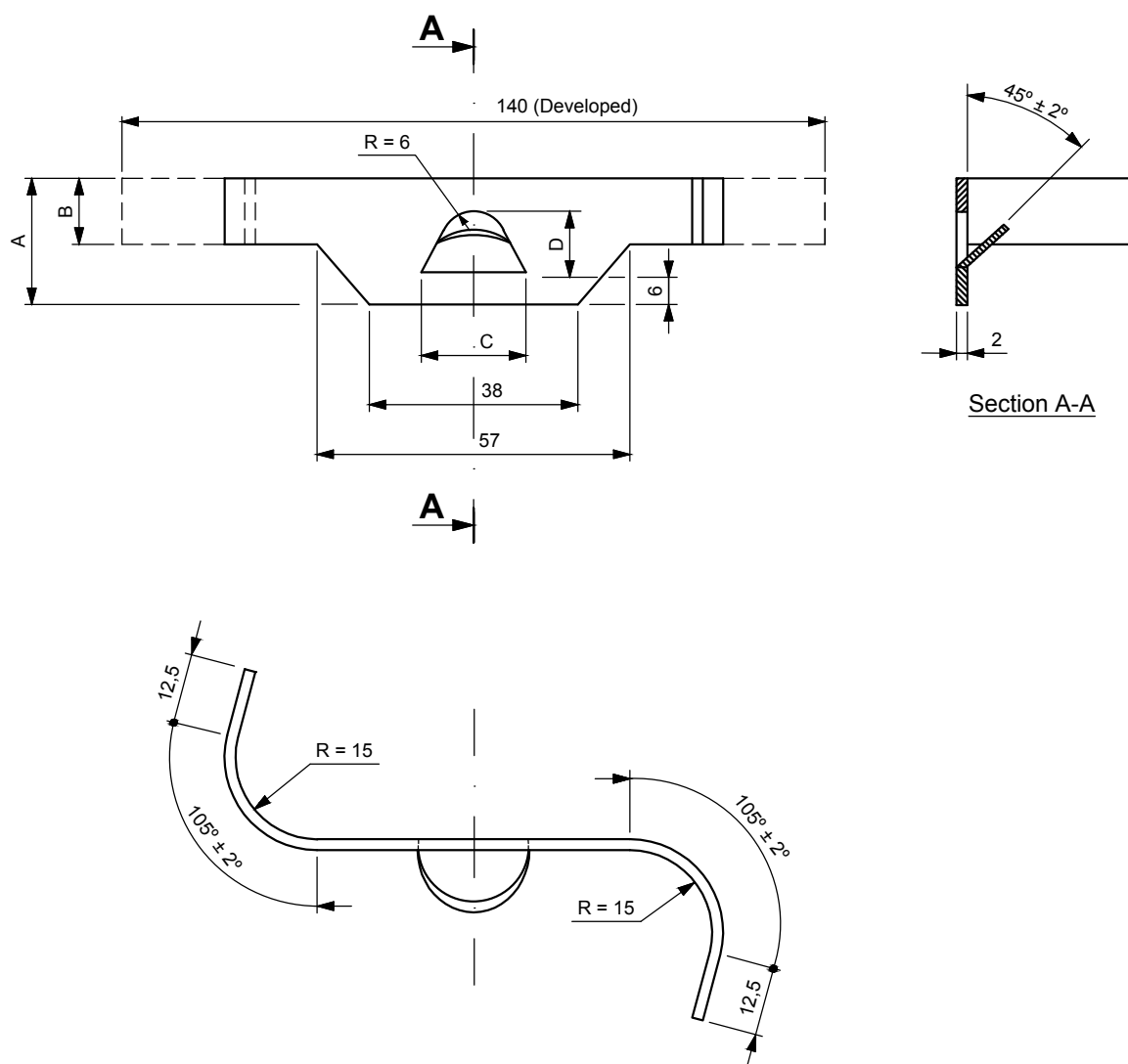


Table - Anchor Dimensions

A	B	C	D
19	10	15	7
25	13	20	13

NOTE 1 Dimensions in millimeters, unless otherwise indicated.

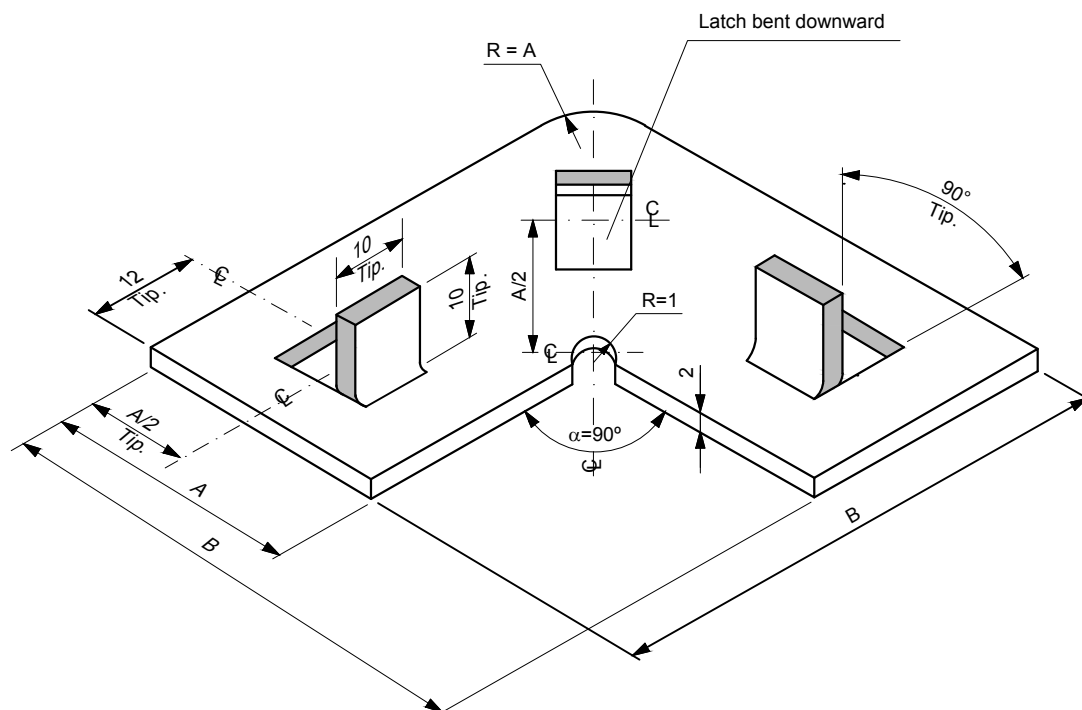
NOTE 2 Overall tolerance: ± 5 %, unless otherwise indicated.

NOTE 3 No burrs.

NOTE 4 A = 19 or 25 mm.

Figure B.11 - "S" Anchor

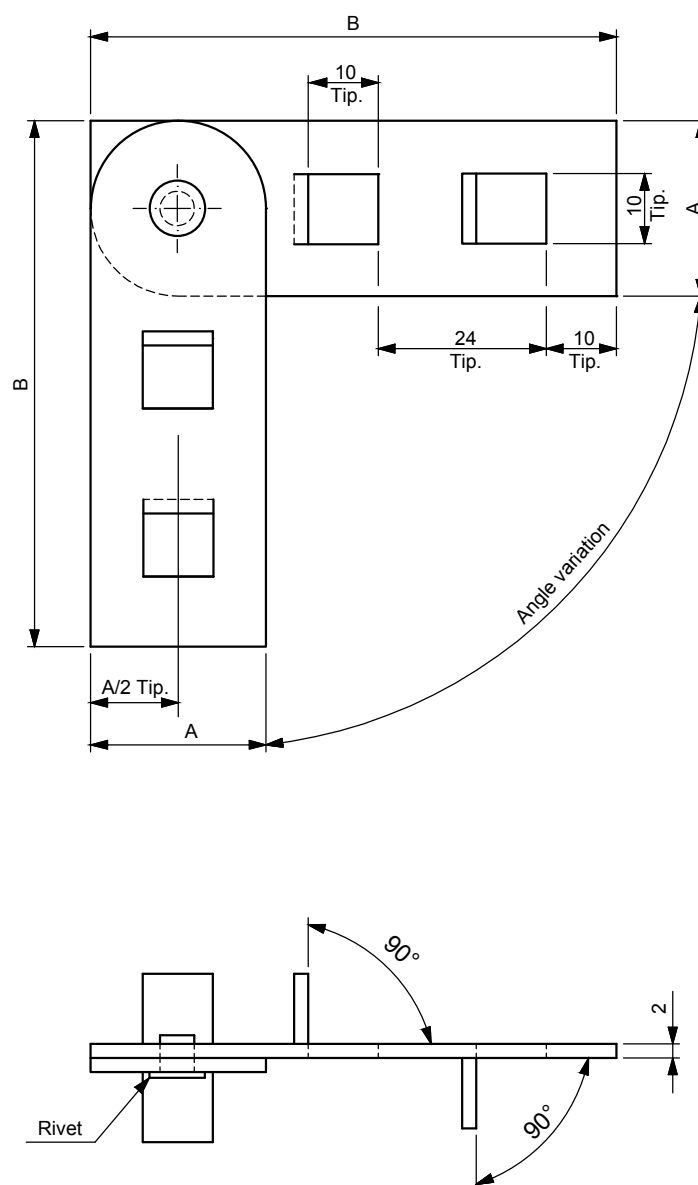




- NOTE 1 Dimensions in millimeters, unless otherwise indicated.  
NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.  
NOTE 3 No burrs.  
NOTE 4 A = 19 or 25 mm and B = 70 mm or according to project.  
NOTE 5 The angle "α" can vary according to project.

**Figure B.12.1 - "L" Anchor - 90°**

### Figure B.12 - "L" Anchors



- NOTE 1 Dimensions in millimeters, unless otherwise indicated.  
 NOTE 2 Overall tolerance  $\pm 5\%$ , unless otherwise indicated.  
 NOTE 3 No burrs.  
 NOTE 4 A = 19 or 25 mm and B = 70 mm or according to project.

**Figure B.12.2 - Articulated "L" - Anchor**

**Figure B.12 - "L" Anchor (Continuation)**

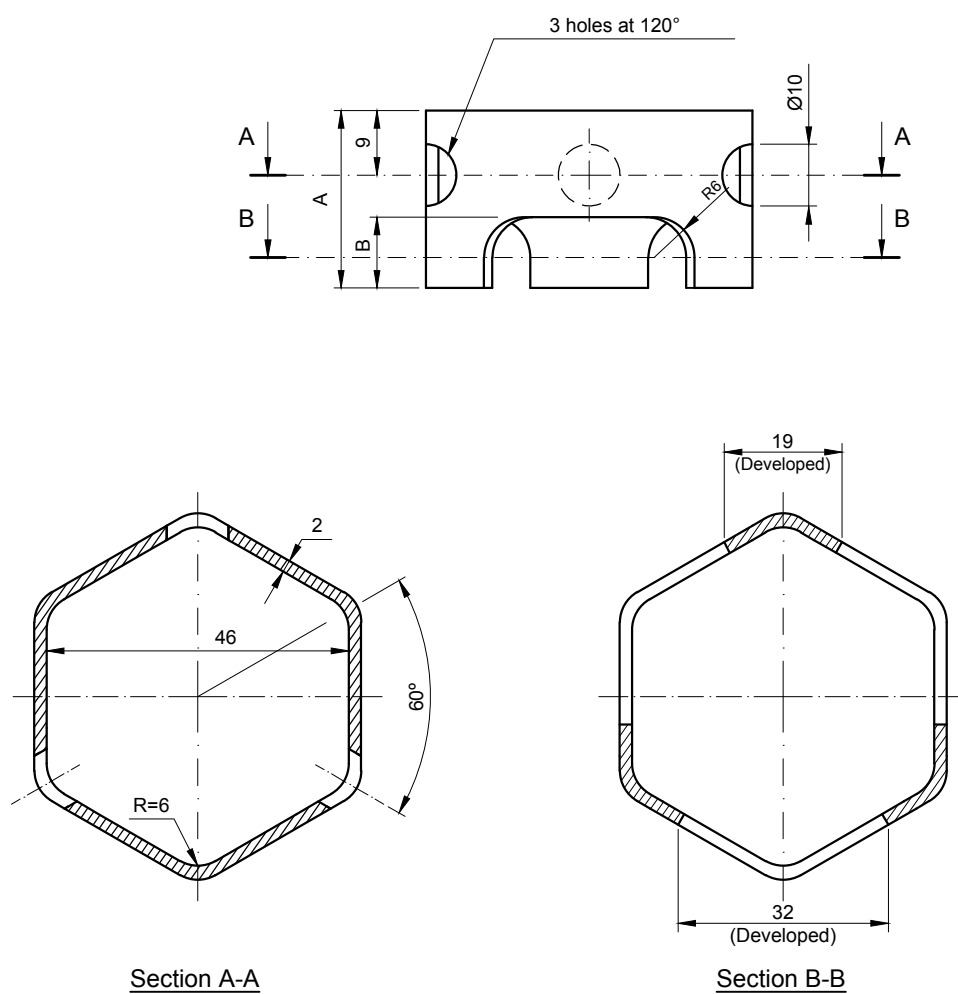


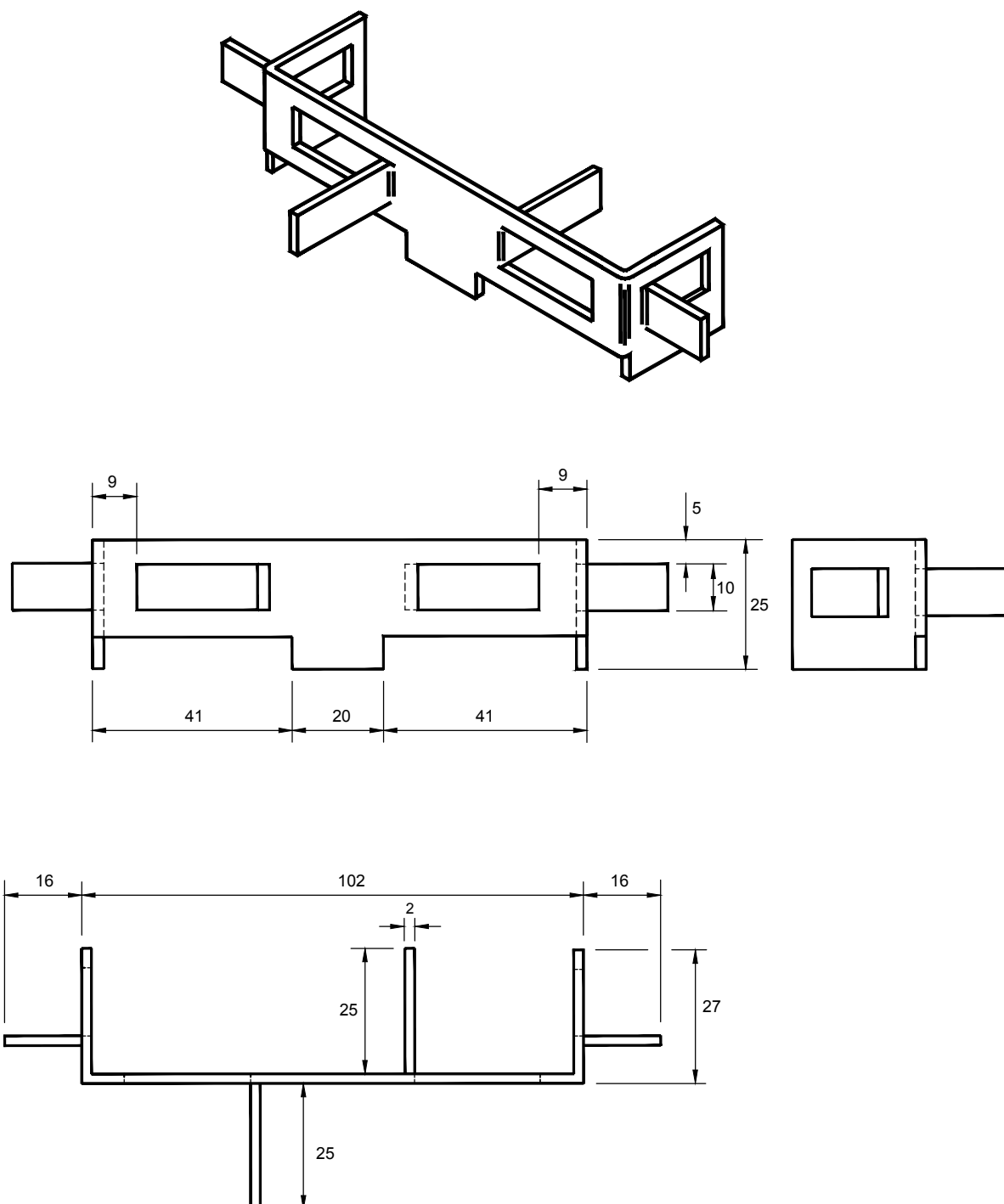
Table - Anchor Dimensions

A	B
25	10
19	8

NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance  $\pm 5\%$ , unless otherwise indicated.

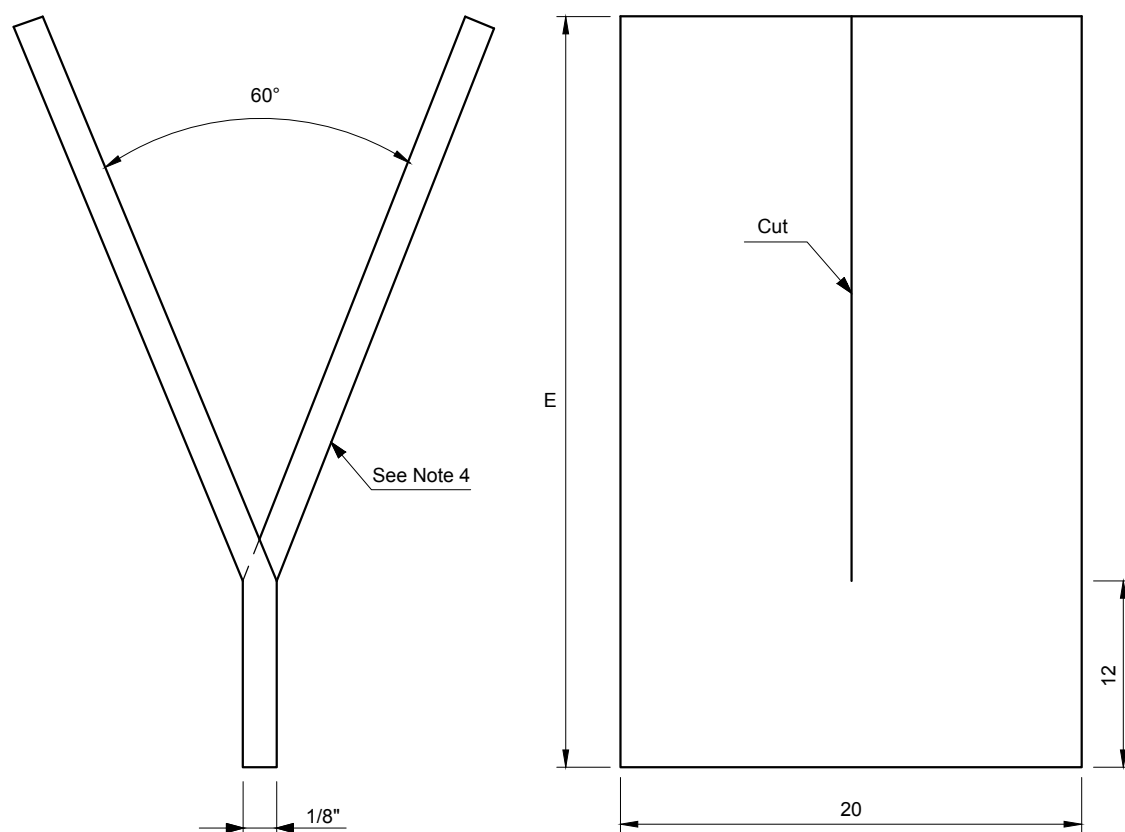
**Figure B.13 - Hexcell Anchor**



NOTE 1 Dimensions in millimeters.

NOTE 2 Overall tolerance  $\pm 5\%$ .

**Figure B.14 - "C" Anchor**



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

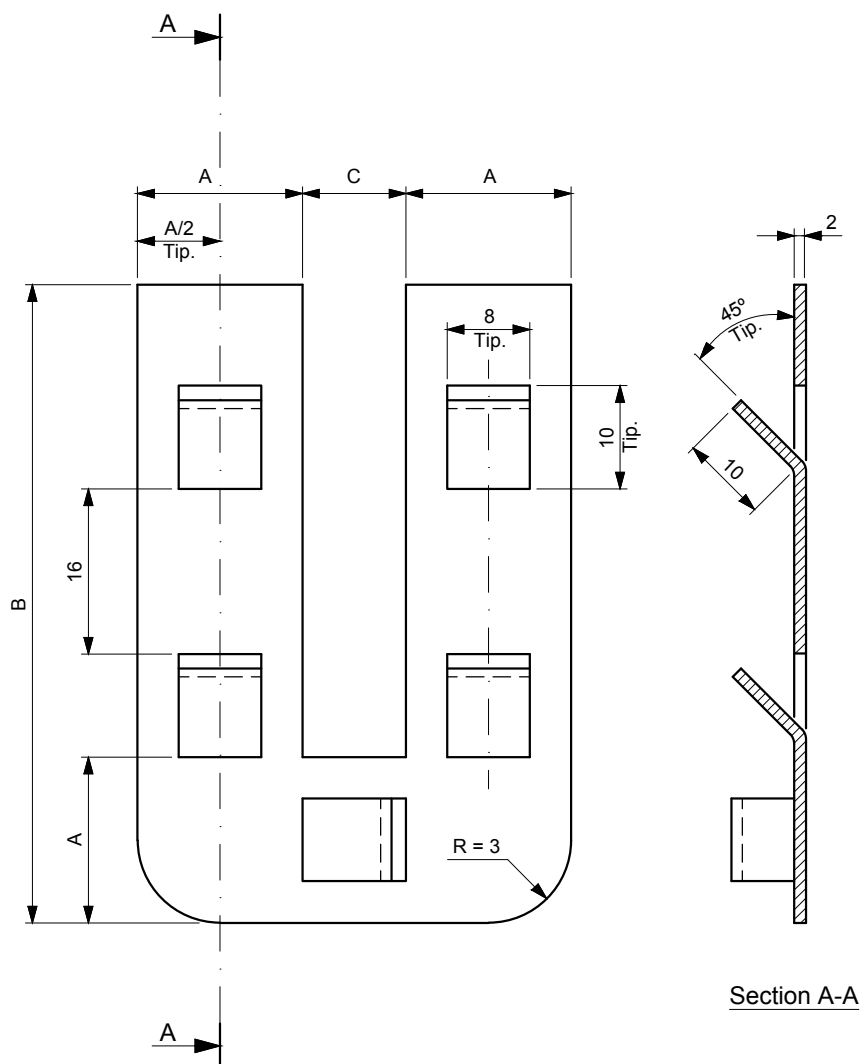
NOTE 2 Overall tolerance  $\pm 5\%$ .

NOTE 3 E = Total thickness of lining.

NOTE 4 Anchor folding after welding.

NOTE 5 No burrs.

Figure B.15 - Slip Y Anchor



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

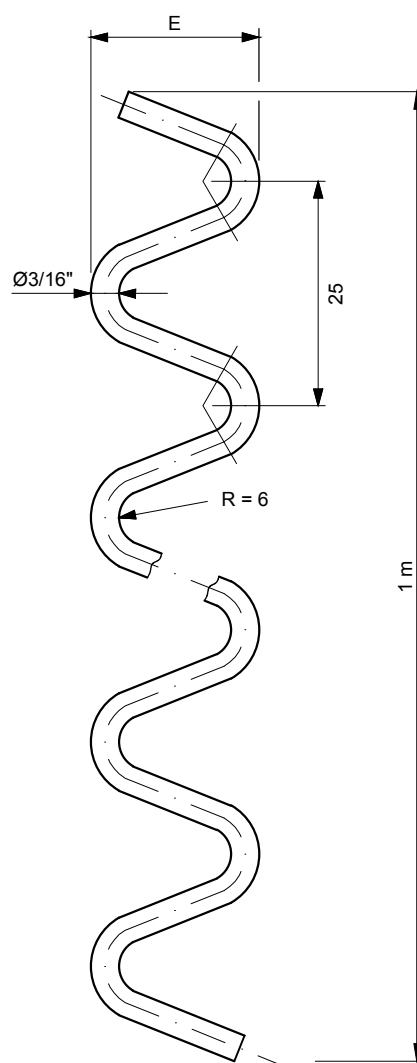
NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 No burrs.

NOTE 4 A = 19 or 25 mm and B = 70 mm or according to project.

NOTE 5 Dimension C = equipment plate thickness (according to project), plus a clearance for assembly of 0,5 mm to 1,0 mm.

**Figure B.16 - "U" Anchor**



NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Overall tolerance:  $\pm 5\%$ , unless otherwise indicated.

NOTE 3 E = thickness of lining (19 or 25 mm).

NOTE 4 Length of anchor 1 m.

Figure B.17 - Star Anchor

## Annex C – Sampling and Specimen Treatment for Castable Refractories and Plastics

C.1 Enter in Table C.1 below the batch size “N” (number of bags) and determine sample size “n”.

**Table C.1 - Sample Size**

“N”	“n”
≤ 200	1
201 - 1 000	2
> 1 000	3

C.2 Manufacture test specimens according to Table C.2.

**Table C.2 – Test Specimens**

Tests	Quantity	Material	Dimensions (mm)	Standard
Cold Crush Strength: - dry at 110 °C  - heated at 815 °C	5	Insulating	114 x 114 x 63	ABNT <a href="#">NBR 11222</a>
	5	Semi-Insulating/ High Dense	50 x 50 x 50	ASTM <a href="#">C133</a>
Abrasion Resistent: - heated at 815 °C	5	High Strength	115 x 115 x 25	ABNT <a href="#">NBR 13185</a> ASTM <a href="#">C704/704M</a>
Permanent Linear Change: - heated at 815 °C	2	All	114 x 114 x 63 or 50 x 50 x 100	ABNT <a href="#">NBR 8385</a> ASTM <a href="#">C113</a>
Bulk Density: - dry at 110 °C		All	Use any one of the TS above	ABNT <a href="#">NBR 11221</a> ASTM <a href="#">C134</a>
NOTE 1 Quantities indicated refer to each bag of the sample. NOTE 2 Apply specimens dimensions as specified, regardless of referenced standard				

C.3 Test individually each test specimen of the sample and write down the “n” values “Xi” of the corresponding parameter tested.

NOTE “Xi” is calculated based on the test method.

C.4 Calculate the average value of “ $\bar{X}$ ” of the results:

$$\bar{X} = \frac{X_1 + X_2 + \dots + X_n}{n}$$

C.5 Rules for decision about the batch:

C.5.1 If “Y” is an upper limit of the respective parameter in Table A.1 of Annex A and:

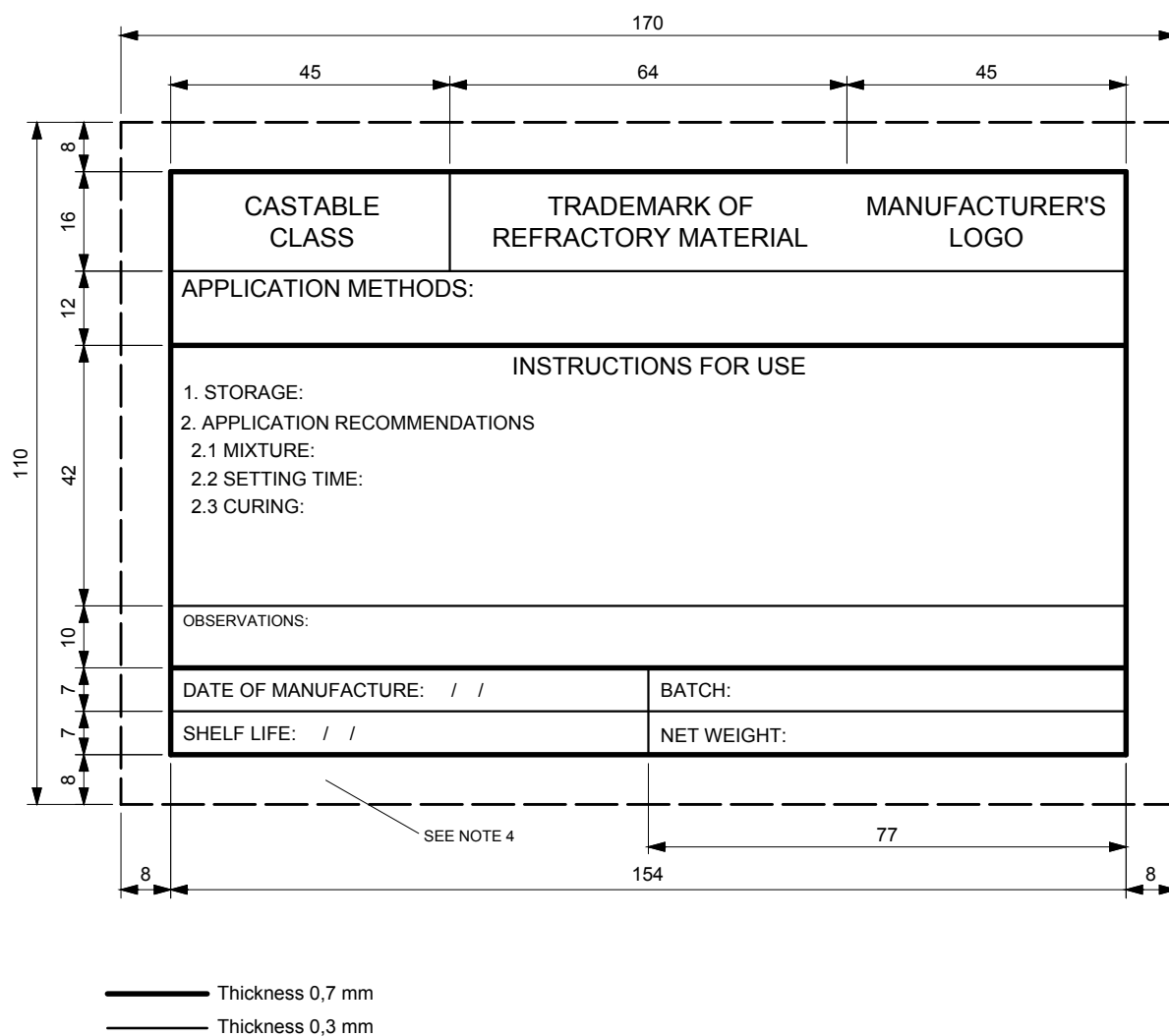
- if  $\bar{X} \leq Y$  accept the batch (see c) of 5.1);
- if  $\bar{X} > Y$  reject the batch.





C-5.2 If "Y" is a lower limit of the respective parameter in Table A.1 of Annex A and:

- a) if  $\bar{X} \geq Y$ : accept the batch (see c) of 5.1);
- b) if  $\bar{X} < Y$ : reject the batch.

**Annex D - Identification Label**


NOTE 1 Dimensions in millimeters, unless otherwise indicated.

NOTE 2 Unscaled drawing.

NOTE 3 The identification label must be affixed (permanently) on the side or on top of all packages. The placement of the label shall allow its viewing even when the bags are stocked on a "pallet".

NOTA 4 The fill color of the border (the region between the dashed line and the main frame) of the label shall be as follows:

High strength Cl. A	Red (Pantone 485C)
High strength Cl. B	Brown (Pantone 463C)
High strength Cl. C	Orange (Pantone 164C)
Regular Cl. A	Dark green (Pantone 575C)
Regular Cl. B	Light green (Pantone 578C)
High alumina	Gray (Pantone 422C)
Plastics (Al-70, Al-80 and Al-90)	Lilac (Pantone 252C)
Semi-insulating	Yellow (Pantone 101C)
Insulating Cl. A	Dark blue (Pantone 288C)
Insulating Cl. B	Medium blue (Pantone 284C)
Insulating Cl. C	Light blue (Pantone 290C)

**Figure D.1 - Identification Label**

INDEX OF REVISIONS	
<b>REV. A, B, C, D, E, F, G e H</b>	
There is no index of revisions.	
<b>REV. J</b>	
Affected Parts	Description of Modification
2	Revised
4.2.1 a 4.2.2	Revised
4.2.5	Revised
4.2.6	Included
4.3.1.3 a 4.3.1.4	Revised
4.3.2	Revised
5.1.2	Revised
5.2	Revised
FIGURES B-1 and B-2	Revised
FIGURES B-4 and B-5	Revised
FIGURES B-9 to B-11	Revised
FIGURE B-12.2	Revised
FIGURES B-14 and B-15	Revised
FIGURES B-16 and B-17	Included
ANNEX C	Revised
<b>REV. K</b>	
Affected Parts	Description of Modification
All	Revised
<b>REV. L</b>	
Affected Parts	Description of Modification
All	Revised