

INTERNATIONAL STANDARD

**ISO
9404-1**

First edition
1991-09-01

Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thick walls —

Part 1 :

Chevron units of 150 mm and 200 mm thickness

*Enceintes pour la protection contre les rayonnements ionisants — Éléments de
blindage en plomb pour murs de 150 mm, 200 mm et 250 mm d'épaisseur —*

Partie 1 : Éléments à chevrons de 150 mm et 200 mm d'épaisseur



Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9404-1 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Sub-Committee SC 2, *Radiation protection*.

ISO 9404 will consist of the following parts, under the general title *Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thick walls*:

- *Part 1: Chevron units of 150 mm and 200 mm thickness*
- *Part 2: Rounded units of 150 mm, 200 mm and 250 mm thickness*

Annex A of this part of ISO 9404 is for information only.

Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thick walls —

Part 1 : Chevron units of 150 mm and 200 mm thickness

Section 1 : General

1.1 Scope

This part of ISO 9404 specifies the properties of the various lead units used in the construction of shielded enclosures for protection against ionizing radiation. The units dealt with are:

- basic units: bricks, posts;
- functional units: aperture bricks, windows, sphere units, plugs and reducing units.

Only bricks for walls of 150 mm thickness are standardized in this part of ISO 9404. Since four- and five-chevron bricks are not manufactured, 200 mm and 250 mm thick walls are constructed with bricks of 50 mm, 100 mm and 150 mm thickness.

The 150 mm and 200 mm shielding units are dealt with separately in two sections for clarity. The 50 mm and 100 mm shielding units are standardized in ISO 7212.

1.2 Classification

The units described in this part of ISO 9404 are classified in three categories:

- **Category 1:** standardized units.

(The diagrams in figures 7, 15, 28 represent the standardized units in category 1.)

- **Category 2:** these are units which are either used very infrequently or for very specialized purposes, or are used very frequently in one country and it is felt that this use will become more widespread.

(The diagrams in figures 16 and 29 represent the standardized units in category 2.)

- **Category 3:** units which are acceptable for a transition period. These are units which are used in one or a few countries and which will be withdrawn from this part of ISO 9404 after the transition period. This category may also include units which were in category 2, but which became less important and will be withdrawn after a transition period in category 3.

1.3 Designation

The designation of the lead shielding unit consists of its name written in full, the reference to this part of ISO 9404 and the reference number as explained in 1.3.1.

EXAMPLE

Aperture brick ISO 9404-1 3V0 202

1.3.1 Explanation of the reference number

The reference number consists of a figure, a letter followed by another figure and a group of three figures, for example 3V0 202:

a) 1st figure: lead thickness

3 = 150 mm 4 = 200 mm

b) letter: encasing profile

V = with chevrons R = rounded form

NOTE — In this part of ISO 9404, only the chevron shielding units are standardized.

c) 2nd figure: assembly direction

1 = assembly direction 1 (see 1.4)

2 = assembly direction 2 (see 1.4)

0 = two assembly directions

d) 3rd, 4th and 5th figures: number specific to each unit.

NOTES

1 A unit which has two different positions inside the shielding wall has the same reference but, according to its position in the wall, the name of its type is different. For example: the base plain brick and the left-hand end ordinary brick have the same reference number: 3V0 100.

2 Throughout the text, it is understood that

— a plain brick is any module of brick having 100 mm × 100 mm dimensions inserted in a wall, which is neither end, corner, nor special;

— an ordinary brick is any module of brick which is neither base nor top.

Except for the cases mentioned in note 2, the last three figures are fixed in series according to table 1.

Table 1 — Series allocation

Units	Series
Plain bricks	100 to 119
Corner bricks	120 to 149
End bricks	150 to 159
Square bricks	170 to 179
X bricks	180 to 189
Posts	190 to 199
Circular aperture bricks	200 to 219
Square or rectangular aperture bricks	250 to 269
Circular windows	300 to 319
Square and rectangular windows	350 to 369
Sphere units	400 to 419
Plugs	500 to 519
Reducing units	600 to 619

In each of these series, a serial number is given to all the units (for example, 3V0 101, 3V0 102, etc.).

1) The dimensions of bricks may vary by a half module.

1.3.2 Explanation of a designation example

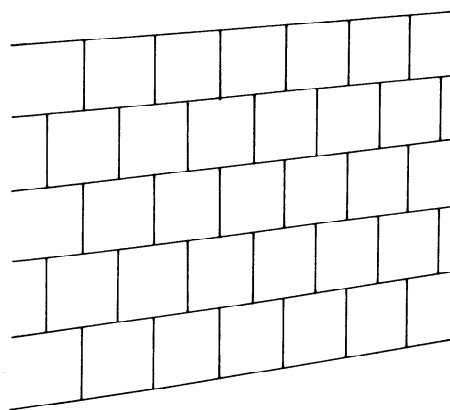
Lead circular aperture brick, 150 mm thickness, three chevrons, two assembly directions, No. 202 (300 mm × 300 mm) shall be designated as follows:

Aperture brick ISO 9404-1 3V0 202

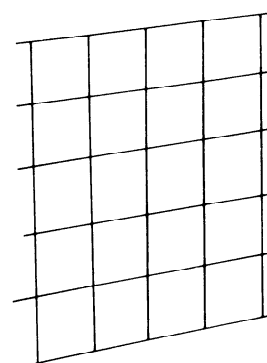
1.4 Specifications of the bricks

1.4.1 General

The dimensions of the category 1 and 2 bricks have been standardized in order to ensure a 100 mm by 100 mm module¹⁾ on installation and, if necessary, to allow staggered joints [see figure 1 a)].



a) Staggered joints



b) Straight joints

Figure 1 — Assembly of bricks

The bricks have two assembly directions (see figure 2):

- assembly direction 1: chevron pointing upwards to the right
 - assembly direction 2: chevron pointing upwards to the left
- } Looking at the enclosure from the outside

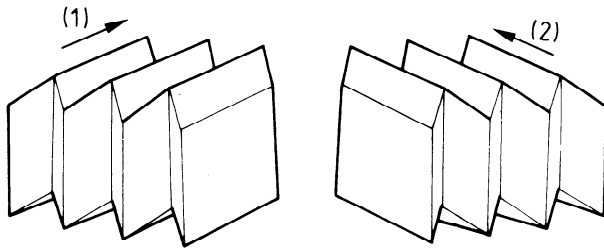


Figure 2 — Assembly directions of bricks

It is recommended that the same assembly direction be used for the entire shielding wall but, if it proves necessary to use the reverse direction, special bricks are used for the join (see 2.1).

A diagram of the basic units of category 1 is given in figure 7.

1.4.2 Properties of the material

The units are made out of an antimonial lead alloy, but they are commonly designated as "lead shielding units".

The surface roughness of the faces is R_a quality 2,8 or better (see ISO 468 and ISO 1302), to give the surface finish required for facilitating decontamination. There shall be no cavities.

The properties of the lead used for the bricks are given in table 2.

Table 2 — Properties of the material

Minimum density of the lead	Percentage of antimony	Minimum hardness
10,9 g/cm ³ 1)	4 ± 0,5	9,5 HB ²⁾
1) This value is not the theoretical value, but that obtained by direct measurement at 20 °C on commercially available units.		
2) The value of 9,5 HB is the minimum which shall be obtained at any point on the brick immediately after casting. The Brinell hardness increases in the first few months after manufacture.		

1.4.3 Profile of the chevron

The specifications relating to the chevron are given in table 3. Figure 3 shows an example of a three-chevron brick.

Table 3 — Specifications of a chevron

Angle of the chevron		Thickness e	Tolerance on height H and length L	Angle on face
Male	Female	mm	mm	
90° + 15' / 0	90° - 0' / - 15'	50 - 0,5	± 0,2	90° ± 10'

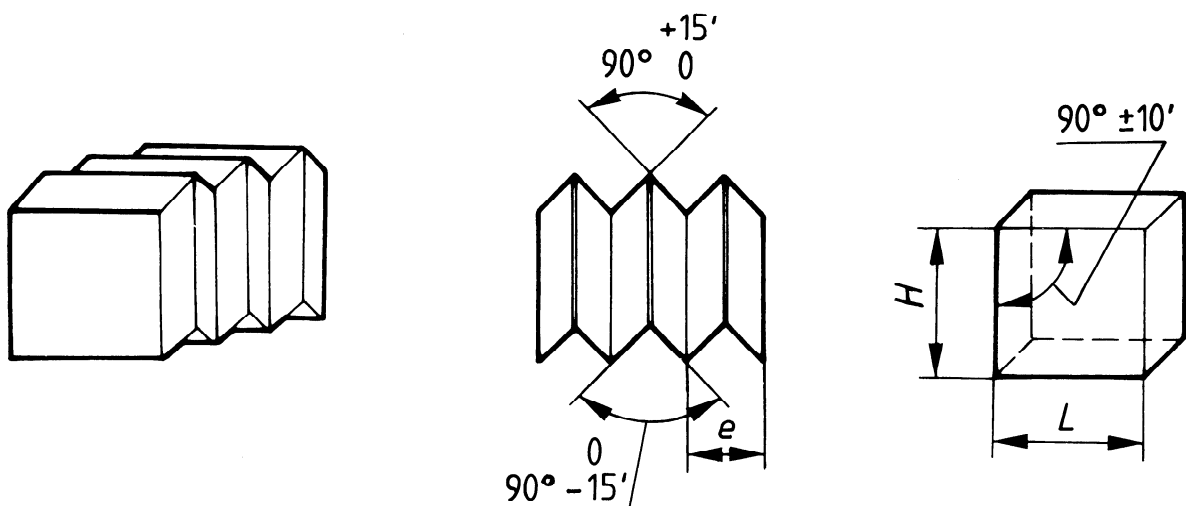


Figure 3 — Example of a three-chevron ordinary plain brick

Bricks with four chevrons are not manufactured except for functional units.

All other parts of a 200 mm thick wall comprise combinations of one-, two- or three-chevron bricks (see figure 4).

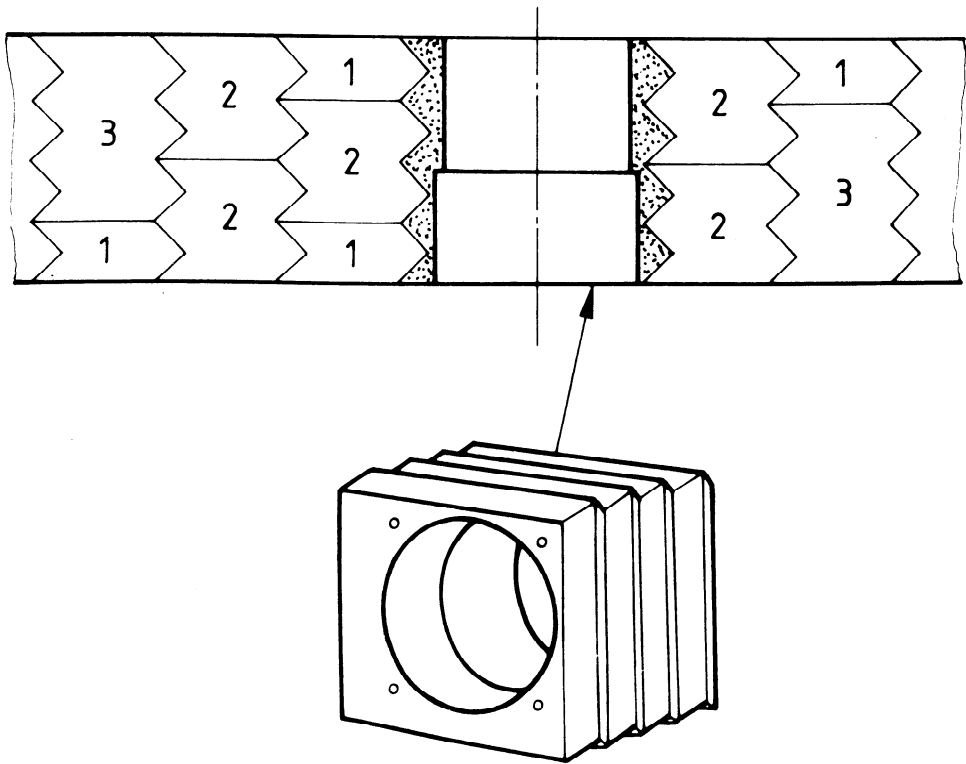


Figure 4 — Example of functional unit with four chevrons — Aperture brick

Section 2 : Lead shielding units — Thickness 150 mm

2.1 Categories 1 and 2

A 150 mm thick wall may be built with three-chevron plain units (see table 4) or, alternatively, by using a combination of one-chevron and two-chevron plain units. For reasons of stability, it is recommended that three-chevron base bricks only be used at the base of a 150 mm thick wall.

Because of their limited use, neither 1/4 plain ordinary bricks nor 1/4 plain top bricks are manufactured with a three-chevron

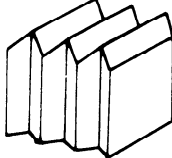
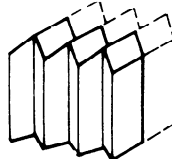
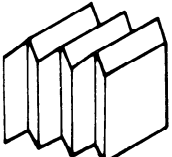
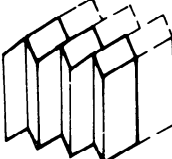
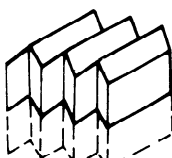
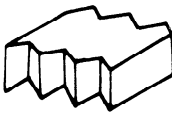
profile. To compensate for this, a combination of one-chevron and two-chevron 1/4 plain ordinary bricks may be used.

2.1.1 Plain bricks

Each type of plain brick may be assembled in each of the two assembly directions.

Table 4 shows the standardized dimensions of category 1, three-chevron plain bricks. The unit module for the designation of bricks is 100 mm × 100 mm.

Table 4 — Category 1 plain bricks

Type	Reference number	Dimensions mm		Diagram	Approximate mass kg
		<i>H</i>	<i>L</i>		
Base plain brick ¹⁾	3V0 100	100	100		19
1/2 base plain brick ²⁾	3V0 101	100	50		9
Ordinary plain brick	3V0 102	100	100		16
1/2 ordinary plain brick ³⁾	3V0 103	100	50		8
		50	100		
1/2 top plain brick ⁴⁾	3V0 105	50	100		6

1) Identical to the 100 × 100 left-hand ordinary end brick (see table 6).

2) Identical to the 50 × 100 1/2 left-hand ordinary end brick (see table 6).

3) This brick may be turned round to constitute an ordinary plain brick 50 mm high and 100 mm long.

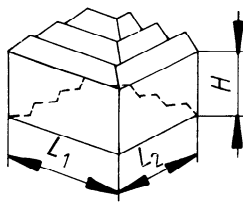
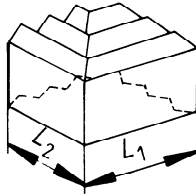
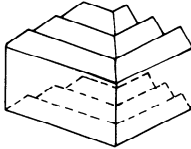
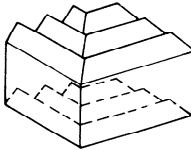
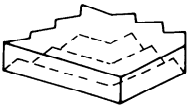
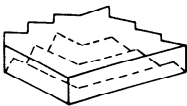
4) Identical to the 100 × 50 1/2 right-hand ordinary end brick (see table 6).

2.1.2 Corner bricks

The dimensions of category 1, three-chevron corner bricks are given in table 5.

Because of their limited use, 1/2 ordinary corner bricks with a three-chevron profile are not manufactured. To compensate for this, a combination of a 1/2 one-chevron corner brick and a 1/2 two-chevron corner brick may be used.

Table 5 — Category 1 corner bricks

Type	Reference number	Dimensions mm			Diagram	Assembly direction*)	Approximate mass kg
		H	L ₁ Re-entrant chevron	L ₂ Projecting chevron			
Base corner brick	3V1 120	100	200	150		(1) 	37
Base corner brick	3V2 121	100	200	150		(2) 	37
Ordinary corner brick	3V1 122	100	200	150		(1) 	33
Ordinary corner brick	3V2 123	100	200	150		(2) 	33
1/2 top corner brick	3V1 126	50	200	150		(1) 	12
1/2 top corner brick	3V2 127	50	200	150		(2) 	12

*) The assembly direction indicated is for convex angle enclosures. For a concave (or reflex) angle:

- either reverse the assembly direction using the same type of corner brick; or
- keep the same assembly direction using the opposite type of corner brick.

See detail on assembly directions in figure 2 and the general diagram in figure 7.

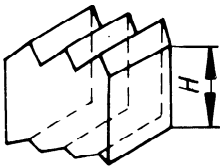
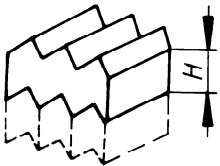
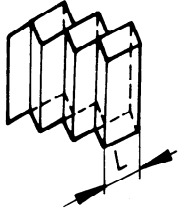
2.1.3 End bricks

Left-hand end bricks for assembly direction 1, when reversed, also serve as right-hand end bricks for assembly direction 2.

Because of their limited use, base end and top end bricks with a three-chevron profile are not manufactured. To compensate for this, a combination of one-chevron and two-chevron base end and top end bricks may be used.

The dimensions of the end bricks for assembly direction 1 are given in table 6.

Table 6 — Category 1 end bricks

Type	Reference number	Dimensions mm		Diagram	Approximate mass kg
		H	L		
Left-hand ordinary end brick ¹⁾	3V0 100	100	100		19
1/2 left-hand ordinary end brick ²⁾	3V0 101	50	100		9
1/2 right-hand ordinary end brick ³⁾	3V0 105	100	50		6
¹⁾ Identical to the 100 × 100 base plain brick (see table 4). ²⁾ Identical to the 100 × 50 1/2 base plain brick (see table 4). ³⁾ Identical to the 50 × 100 1/2 top plain brick (see table 4).					

2.1.4 Special bricks

Special bricks are used to reverse the assembly direction and are made for walls of 50 mm lead thickness; for walls of 150 mm thickness, three special bricks are used side by side.

There are two types of special bricks: square bricks and X bricks, the assembly directions of which are shown in figures 5 and 6, respectively.

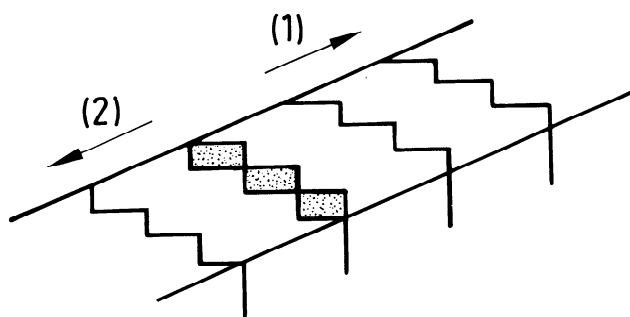


Figure 5 — Assembly of square bricks

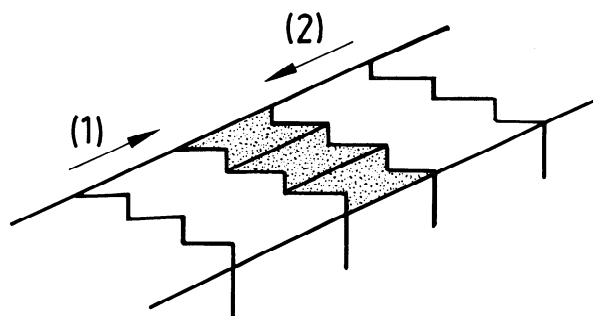


Figure 6 — Assembly of X bricks

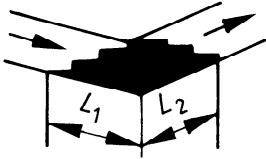
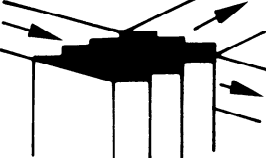
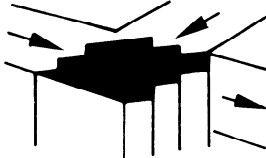
2.1.5 Posts

Posts are used to provide a framework for the brick enclosures.

When used, external tie rods and rigid angle bars can be attached.

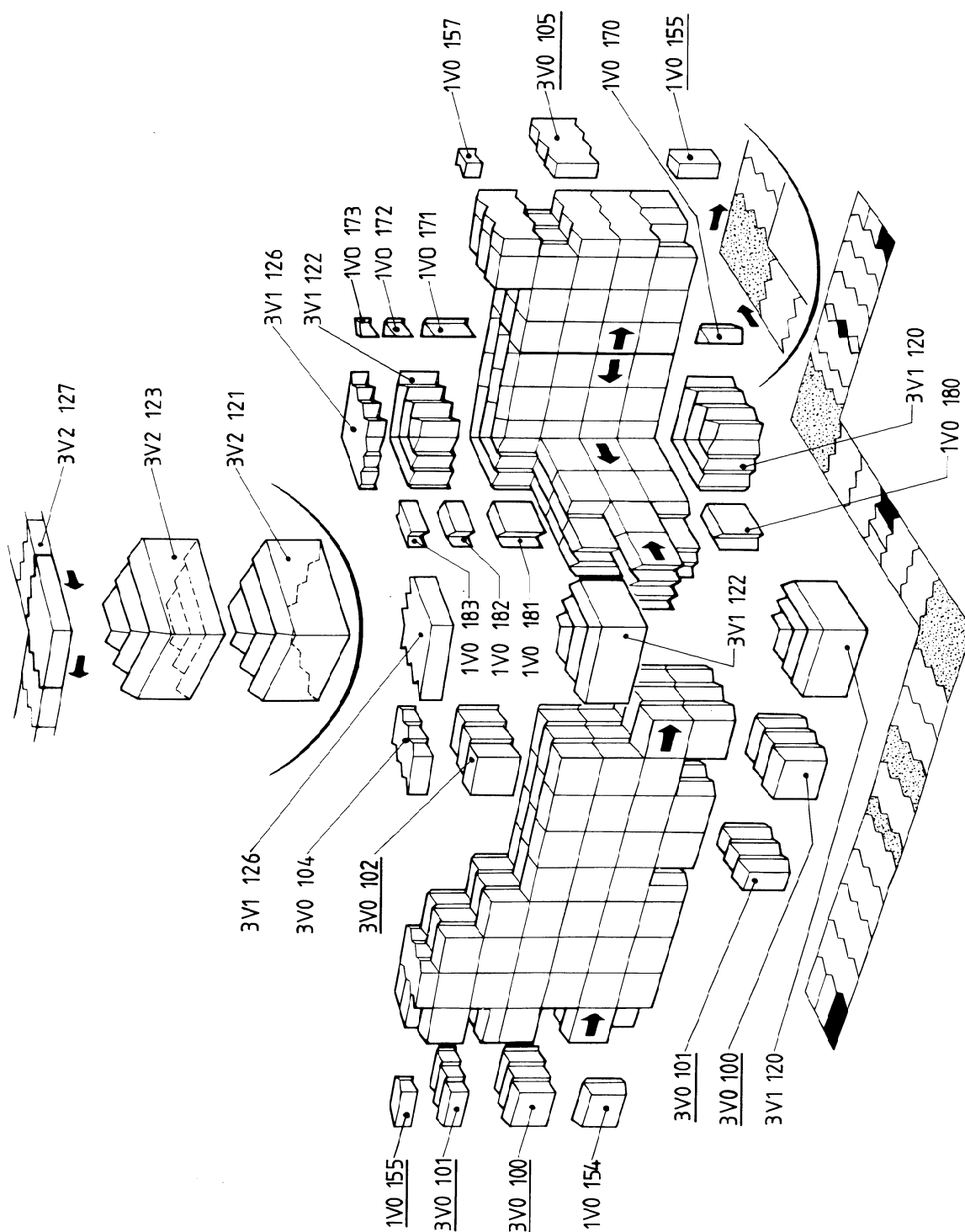
These posts have a maximum height of 3 m; they are made either of antimonyated lead or soft lead cast on a steel frame.

Table 7 — Category 2 posts (assembly direction 1)¹⁾

Type	Reference number	Section mm		Diagram	Approximate mass kg
		L ₁ Re-entrant chevron	L ₂ Projecting chevron		
Corner post	3V0 190	150	150		250
T-post 2MF (2 male, 1 female)	3V0 191	150	150		270
T-post 2FM (2 female, 1 male)	3V0 192	150	150		230
1) By turning these posts upside down, assembly direction 2 is obtained.					

2.1.6 Assembly of basic units

A general diagram of the disposition of the basic units, 150 mm thick, is shown in figure 7 for the units of category 1.



The underlined reference numbers indicate that the corresponding bricks have two positions in the wall.

Figure 7 — General diagram of disposition of category 1 basic units for walls 150 mm thick

2.1.7 Aperture bricks

Externally, three-chevron aperture bricks are square or rectangular and their internal dimensions are standardized so that the units they hold may be interchanged (see figures 8 and 9).

The dimensions of aperture bricks for a lead thickness of 150 mm are given in tables 8, 9, 10 and 11.

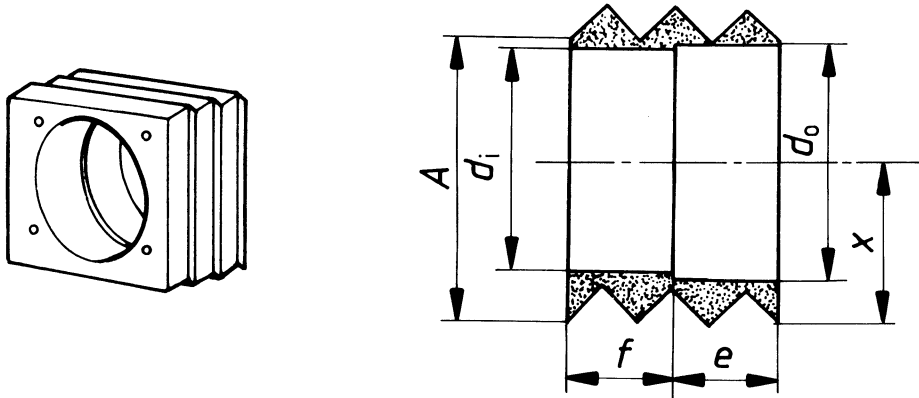


Figure 8 — Aperture brick for circular units

Table 8 — Category 1 aperture bricks for circular units

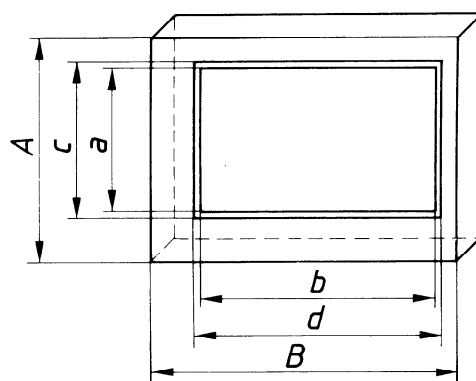
Reference number	$A \times A$	x	d_i	d_o	e	f	Approximate mass kg
	mm						
3V0 200	200 × 200	112,5	170	172	72	76,25	30
3V0 202	300 × 300	162,5	266	270	70	76,5	50
3V0 204	400 × 400	212,5	366	370	70	76,5	90

NOTE — If, in special cases, an aperture brick is turned through 180° around the axis of the aperture to change the direction of assembly, it should be noted that, taking into account the chevron, the centreline of the aperture is offset 25 mm from the centreline of the face of the brick.

Table 9 — Category 2 aperture bricks for circular units

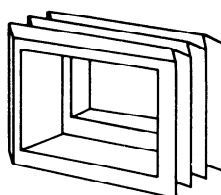
Reference number	$A \times A$	x	d_i	d_o	e	f	Approximate mass kg
	mm						
3V0 207	200 × 200	112,5	150	160	75	75	30
3V0 209	250 × 250	137,5	195	205	75	75	50
3V0 211	300 × 300	162,5	240	250	75	75	70
3V0 213	350 × 350	187,5	285	295	75	75	110

NOTE — If, in special cases, an aperture brick is turned through 180° around the axis of the aperture to change the direction of assembly, it should be noted that, taking into account the chevron, the centreline of the aperture is offset 25 mm from the centreline of the face of the brick.

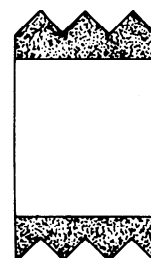


a) Cut

External

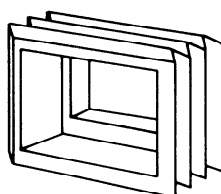


Internal

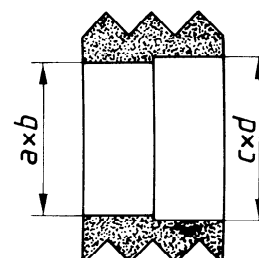


b) Category 1, without step

External

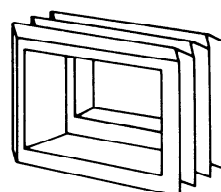


Internal

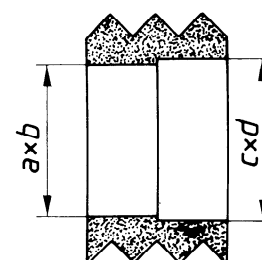


c) Category 1, with step ($e = f$)

Internal



External



d) Category 2, with step and inner redan ($e \neq f$)

Figure 9 — Aperture bricks for square and rectangular windows

Table 10 — Category 1 aperture bricks for square and rectangular windows

Reference number	$A \times B$	Window mounting						Type and shape of window	Approximate mass kg
		a	b	c	d	e	f		
		mm							
3V0 263	600 × 800	455	655	455	655	150	0 ¹⁾	Rectangular 400 × 600	145
3V0 264	800 × 1 000	655	855	655	855	150	0 ¹⁾	Rectangular 600 × 800	370
3V2 265	600 × 900	491	791	511	811	75	75	Rectangular 400 × 700	165 ²⁾
3V2 266	550 × 650	421	511			75		Rectangular 330 × 420 external	155 ²⁾
				441	531		75	330 × 420 internal	
3V2 267	800 × 1 000	691	891			75		Rectangular 500 × 700 external	200 ²⁾
				711	911		75	600 × 800 internal	

1) No step.

2) These aperture bricks are made solely of steel.

NOTE — If, in special cases, an aperture brick is turned through 180° around the vertical axis of the aperture to change the direction of assembly, it should be noted that, taking into account the chevron, the centreline of the aperture is offset 25 mm from the centreline of the face of the brick.

Table 11 — Category 2 aperture bricks for square and rectangular windows¹⁾

Reference number	$A \times B$	Window mounting						Type and shape of window	Approximate mass kg
		a	b	c	d	e	f		
		mm							
3V1 268	650 × 850	455	655			100		Rectangular 400 × 600 external	305
				555	755		50	500 × 700 internal	
3V1 269	750 × 950	555	755			50		Rectangular 500 × 700 external	345
				655	855		100	600 × 800 internal	

1) Unlike category 1 aperture bricks, category 2 aperture bricks have an inner redan [see figure 9d) and the note to figure 11d)].

2.1.8 Windows

The minimum average density of the glass is $5,2 \text{ g/cm}^3 \pm 0,02 \text{ g/cm}^3$.

The minimum thickness of glass is 330 mm.

NOTE — The shielding value of the glass blocks fitted in these window assemblies is calculated using cobalt-60 as the radiation source.

In certain circumstances, and particularly at lower energies, this may result in windows not providing shielding equal to that of the lead wall for which they were designed. This case may require a special design.