INTERNATIONAL STANDARD

ISO 29584

First edition
2015-12-01

Glass in building — Pendulum impact testing and classification of safety glass

Verre dans la construction — Essai d'impact au pendule et classification du verre de sécurité

Reference number
ISO 29584:2015(E)

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*.

This first edition cancels and replaces ISO/TS 29584:2012, which has been technically revised.

Introduction

Accidental human impact with glass panes can be a source of injury. The classification of glass in terms of its ability to withstand impact and the consequences of the glass breaking under such impact has been considered in many countries. The use of a soft body impactor to represent a human body has enabled regulators, code officials and other control organizations to specify glazing that reduces the risk of cutting and piercing injuries.

This International Standard has been prepared as a means of detailing the differences and similarities in pendulum impact tests for the classification of safety glass.

The traditional impactor has been a lead shot-filled leather bag. This has been found to suffer from ageing or shape change and variability in the energy transfer into the test piece if not properly maintained. It has been found that there can be wide variation in the supporting frame or sub-frame.

During their work, CEN /TC 129/WG 13 examined some of the problems associated with the lead shot-filled leather bag impactor and the supporting frame. CEN/TC 129/WG 13 prepared EN 12600 that uses an impactor consisting of steel masses and two tyres.

The primary objectives in developing the new impactor for the evaluation of safety glass can be summarized as follows:

a) elimination of the differences between

   1) taped and un-taped lead shot bags and

   2) lead shot bags and bags filled with sand or glass beads;

b) ageing of lead shot bag;

c) elimination of the use of lead shot;

d) harmonization of national impact test methods.

Glass in building — Pendulum impact testing and classification of safety glass

1 Scope

The purpose of this International Standard is to evaluate, by means of soft body impactors, safe breakage characteristics of glazing products intended to reduce cutting and piercing injuries to persons through accidental impact.

This International Standard examines test methods currently employed to determine the pendulum impact performance of safety glass. Use of the methodologies in this International Standard improves the reproducibility of test results and gives a common basis of classification. The aim is for the performance of glass products manufactured and tested in various countries to be better understood and more consistent.

Two types of soft body impactors are defined. The traditional shot bag impactor is detailed both in terms of manufacture and maintenance in an attempt to overcome problems associated with such impactors becoming misshapen. The twin tyre impactor is also detailed.

The test equipment, excluding the impactor, is also described. A method of calibrating the test frame is given. The benefit of calibrating the test equipment is the increased reproducibility of the test results.

Classification of glass products is also detailed. The classification system allows information on the following to be given:

a) the maximum drop height at which the glass either did not break or broke safely, i.e. in a manner similar to laminated glass or toughened glass;

b) the manner in which the glass would break, i.e. as toughened glass, laminated glass, annealed glass, irrespective of whether or not the glass was broken during the test;

c) the maximum drop height at which the glass either did not break or broke safely, i.e. in a manner similar to laminated glass.

This International Standard does not specify the intended use of the products, but provides a method of classification in terms of the performance of the materials being tested. The impact energy used for the various levels of classification are designed to provide the intended user or the legislator with the information to assist in defining the level of safety and protection required relative to the intended location at which the selected safety glass is to be used.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 2408, *Steel wire ropes for general purposes — Minimum requirements*

ISO 4251-1, *Tyres (ply rating marked series) and rims for agricultural tractors and machines — Part 1: Tyre designation and dimensions, and approved rim contours*

3 Terms and definitions

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

3.1
safety glass
glazing material so treated, constructed or combined with other materials that, if fractured or broken by accidental human contact, gives fragments which are less likely to pierce or to cause severe cuts than fragments of ordinary annealed glass, or the likelihood of cutting and piercing injuries that might result from such contact is minimized by glass shard containment

EXAMPLE Laminated glasses and thermally toughened glasses are types of safety glazing material.

3.2
soft body impactor
impactor that is representative of a human body

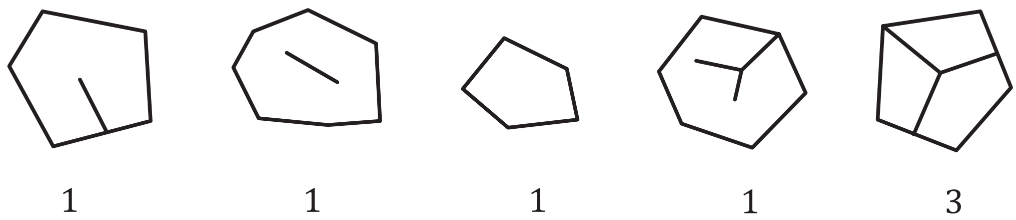
EXAMPLE A soft body impactor can be either a shot bag (see 5.1.3.1) or a twin tyre (see 5.1.3.2) type.

3.3
asymmetric material
glass that has different surface characteristics on opposite faces, e.g. patterning, coating, or manufactured from laminations of glass or plastics glazing sheet material together with interlayer materials that are arranged in different sequential order and of varying thicknesses

3.4
drop height
vertical height from the horizontal centre line of the impactor at the point of release to the horizontal centre line of the impactor when at rest vertically

3.5
crack-free particle
piece of glass that does not contain any cracks that run from one edge to another

Note 1 to entry: See Figure 1.



Key
1, 3 numbers of crack free particles in each piece of glass

Figure 1 — Example of crack free particles

3.6
masking
temporary protective covering applied to the test piece for ease of transportation

4 Test requirements

4.1 When tested by the method given in Clause 5, each test piece shall either not break or shall break as defined in one of 4.2 and 4.3.

4.2 Numerous cracks appear, but no shear or opening is allowed within the test piece through which a (76 ± 1) mm diameter sphere can pass when a maximum force of 25 N is applied (in accordance with Annex C).

Additionally, if particles are detached from the test piece up to 3 min after impact, they shall, in total, weigh no more than the mass equivalent to 10 000 mm^2 of the original test piece. The largest single particle shall weigh no more than the mass equivalent of 4 400 mm^2 of the original test piece. Within 5 min of impact and disintegration occurs the 10 largest crack-free particles collected shall weigh no more than the mass equivalent to 6 500 mm^2 of the original test piece. The particles shall be selected only from the portion of the original test piece exposed in the test frame. Only the exposed area of any particle retained in the test frame shall be taken into account in determining the mass equivalent.

4.3 The 10 largest crack-free particles collected within 3 min after impact shall weigh no more than the mass equivalent of 6 500 mm^2 of the original test piece.

5 Test method

5.1 Test apparatus

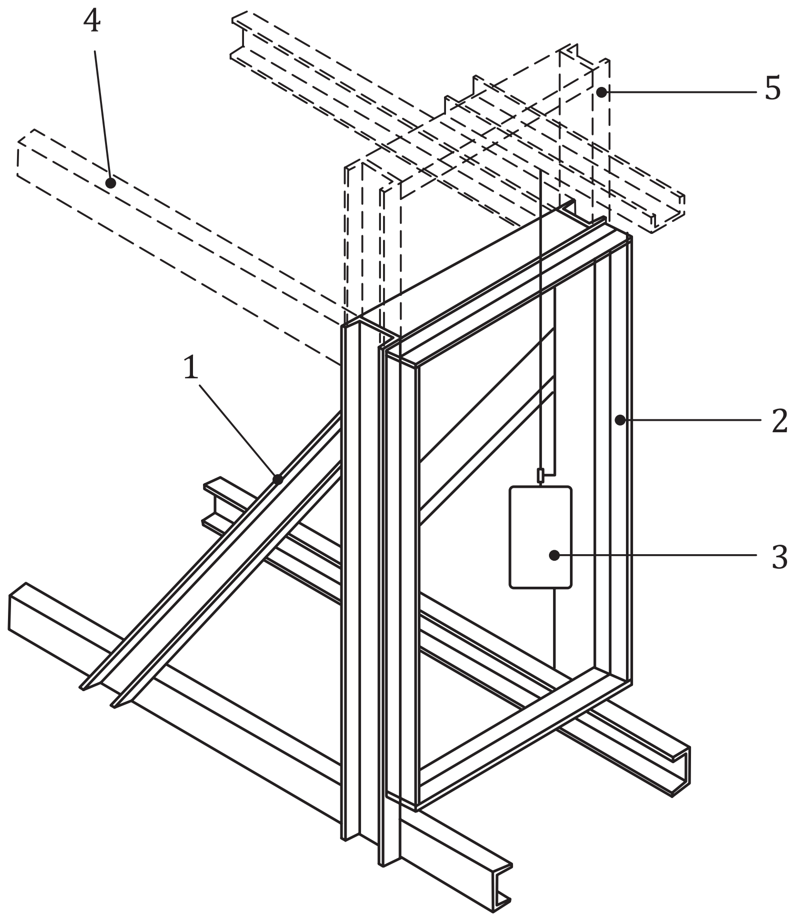
5.1.1 Main frame, constructed from welded or bolted, hot-rolled steel channel sections with rounded edges, designed to present a rigid and flat surface to the sub-frame. See Figures 2 and 3. The lower cross members shall be securely fixed to a concrete floor.

NOTE Additional support to the frame can be provided, if required, by means of horizontal steel sections fixed to an adjacent rigid wall (see Figure 2, key 4).

The dimensions of the main frame (see Figure 4) shall be as follows:

a) internal width: (847 ± 5) mm;

b) internal height: (1 910 ± 5) mm.



Key

1 main frame

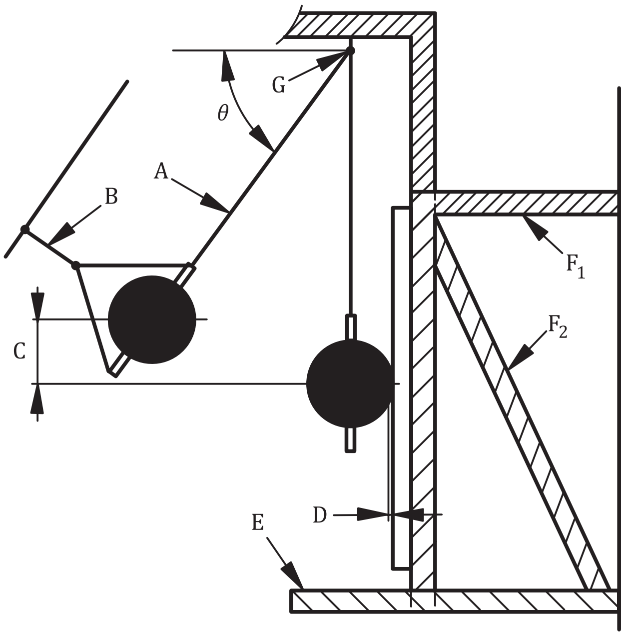
2 clamping frame

3 impactor

4 optional support member

5 optional suspension device

Figure 2 — Test frame



Key

A suspension cable

B traction cable

C drop height

D impactor distance from sample

E support member

F_1 optional support member

F_2 cross members

G bracket (5 mm ≤ d ≤ 15 mm)

θ impactor angle from horizontal

Figure 3 — Side elevation of the main frame with the impactor

Dimensions and tolerances in millimetres

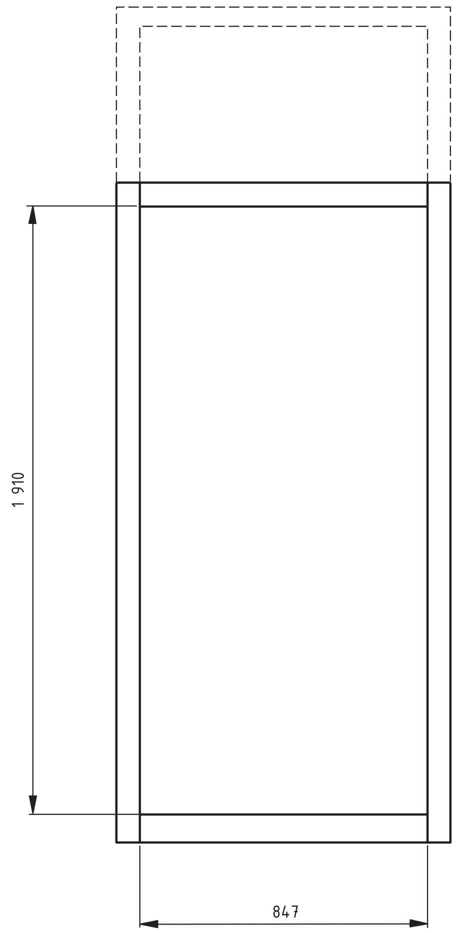


Figure 4 — Dimensions of the front elevation of the frame

5.1.2 Clamping frame, fitted on to the main frame and used to hold the test piece in position for the duration of the test, consisting of two rectangular parts which clamp the test piece along its perimeter. See Figure 5. The inner part of the clamping frame is attached to the main frame.

The assembly is held together by a clamping device. The clamping frame shall be suitably rigid to withstand the pressure exerted by the clamping device.

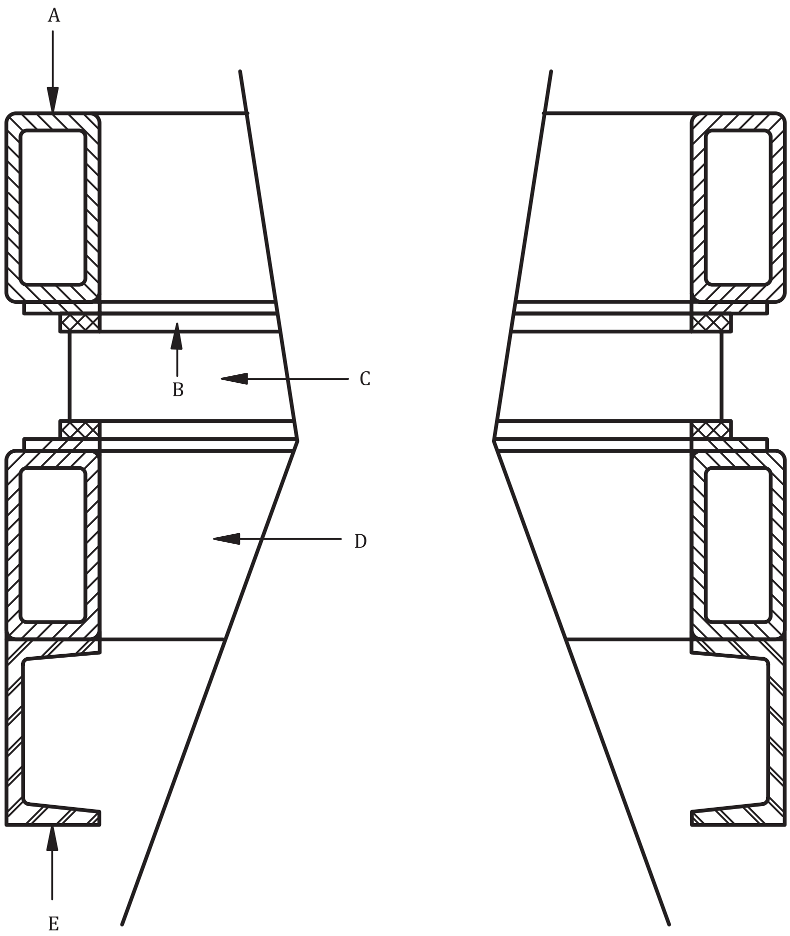
The dimensions of the clamping frame shall be as follows:

a) internal width: (847 ± 5) mm;

b) internal height: (1 910 ± 5) mm.

Each part of the clamping frame shall be fitted with a strip of rubber. The rubber strips shall be the only element in contact with the test piece and shall be (20 ± 2) mm wide and (10 ± 1) mm thick and have a hardness of (60 ± 5) IRHD in accordance with ISO 48.

NOTE Polychloroprene (polychloroprene) or a similar material is suitable.



Key

A clamping frame, e.g. ~100 mm × 50 mm × 8 mm

B rubber strips (20 ± 2) mm × (10 ± 1) mm

C test piece

D outer part of the main frame, e.g. ~100 mm × 50 mm × 8 mm

E inner part of the main frame, e.g. ≤100 mm × 50 mm

Figure 5 — Example of clamping of the test piece

5.1.3 Impactor, of type 5.1.3.1 or 5.1.3.2, suitable for use with the suspension device (5.1.4) and release mechanism (5.1.5).

5.1.3.1 Lead shot bag.

5.1.3.1.1 General description.

The bag (see Figure 6) is a reinforced leather bag filled with chilled lead shot of diameter (2,5 ± 0,1) mm providing a total mass of (45 ± 0,1) kg. The bag is constructed of 1,5 mm thick pliable leather (see Figure 7).

5.1.3.1.2 Method of manufacture.

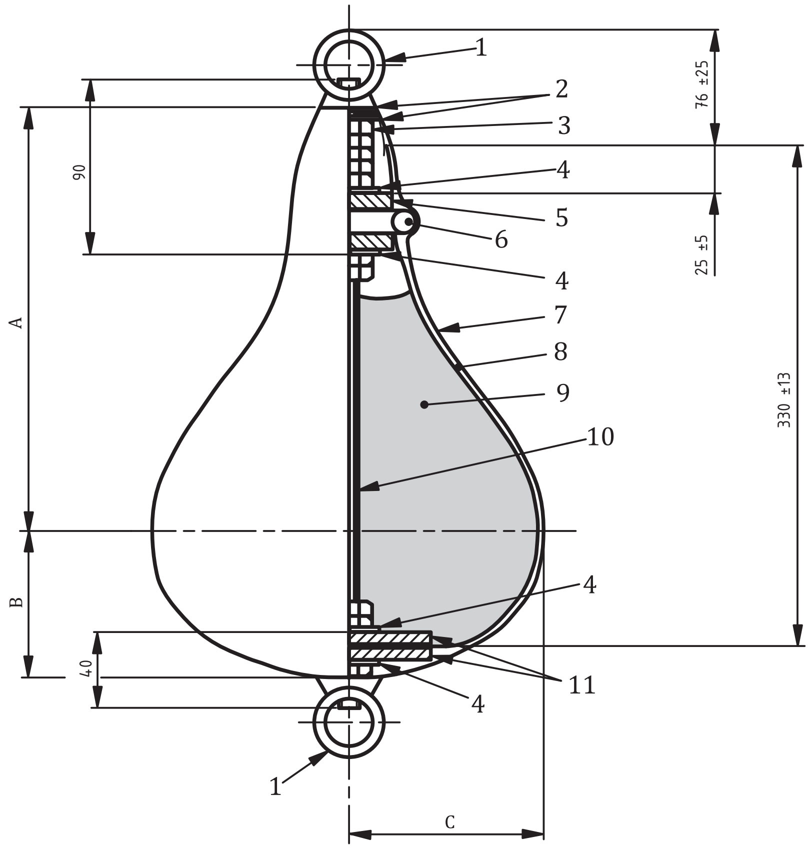
See Annex A.

5.1.3.1.3 Maintenance. Inspect the shot bag impactor at intervals of 1 000 impacts and calibrate as required. If the tape of the impactor is damaged (e.g. when glass fibres are apparent, or the leather bag is visible), it shall be removed and replaced according to Annex A. When the deformation of the impactor is beyond the tolerances, the impactor shall be reshaped manually. If the impactor cannot be restored to within the tolerances, it shall be replaced.

Remove all glass particles embedded in the surface of the impactor.

The tolerances of dimensions for the impactor are shown in Figure 6.

Dimensions and tolerances in millimetres



Key

		No. required	Remarks
1	eye nut	2	M10
2	plane washer	2	M10
3	hexagonal nut	10	M10
4	spring washer	4	M10
5	sleeve nut	1	length: 25 mm; diameter: 32 mm
6	hose clamp	1	
7	glass fibre-reinforced adhesive polyester tape (see Note 2)	3 rolls	width: 12 mm; thickness: 0,15 mm
8	leather bag	1	synthetic leather (see Note 1)
9	lead shot	~45 kg	chilled shot, diameter: (2,5 ± 0,1) mm
10	threaded metal rod	1	M10 Length: 400 mm
11	metal washer	2	thickness: (4,8 ± 1,6) mm;diameter: (76 ± 3) mm

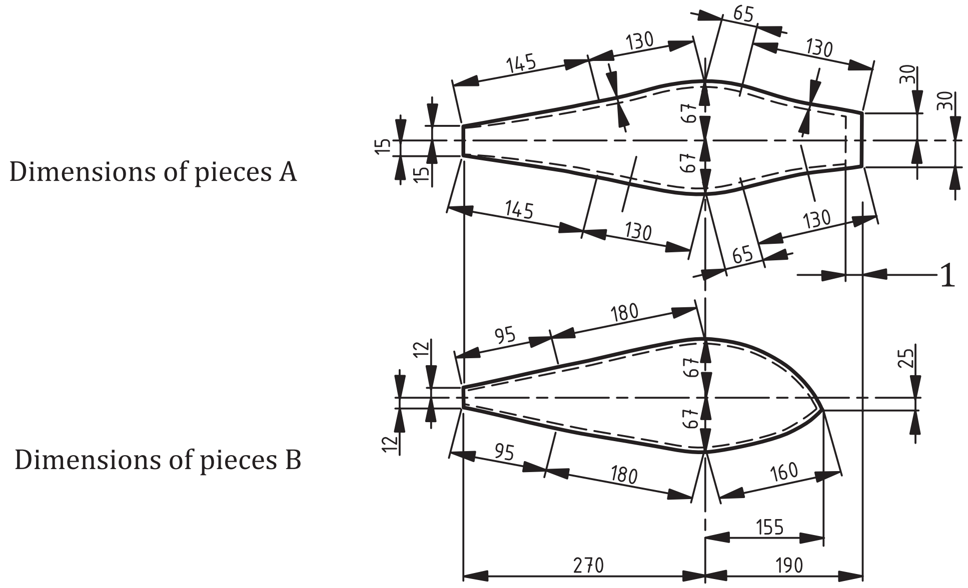
NOTE 1 The bag is made of the synthetic leather of thickness 1,5 mm by seaming up with two sheets of piece A (see Figure 7) and four sheets of piece B (see Figure 7). The margin to seam between pieces A and B is about 4 mm. The Model SB-4500[1)] is the trade name of a product supplied by Wining KK.

NOTE 2 3 M N° 898 is the trade name of a product supplied by 3M Company.[2)]

Figure 6 — Plan of shot bag impactor

1) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.



Key

1 margin to seam 16 mm

Figure 7 — Dimensions of pieces of shot bag impactor

5.1.3.2 Twin tyre impactor.

5.1.3.2.1 General description

Impactor consisting of two pneumatic tyres, e.g. tyre 3.50-8/4PR[3] or Continental T7[3], in accordance with ISO 4251-1, with round section and flat longitudinal tread. See Figure 8. The tyres shall be fitted to the rims of the wheels that carry two equal steel masses. The masses shall be dimensioned so that the total mass of the impactor is (50 ± 0,1) kg.

NOTE The tyre specified for this impactor, while in accordance with ISO 4251-1, has been found to have performance variations dependent on site and country of manufacture. This variation can cause problems with the calibration, but has not been found to affect product classification.

5.1.3.2.2 Method of manufacture

An example of the impactor, using steel with a density of 7 830 kg/m^3, is shown in Figure 8.

5.1.3.2.3 Maintenance

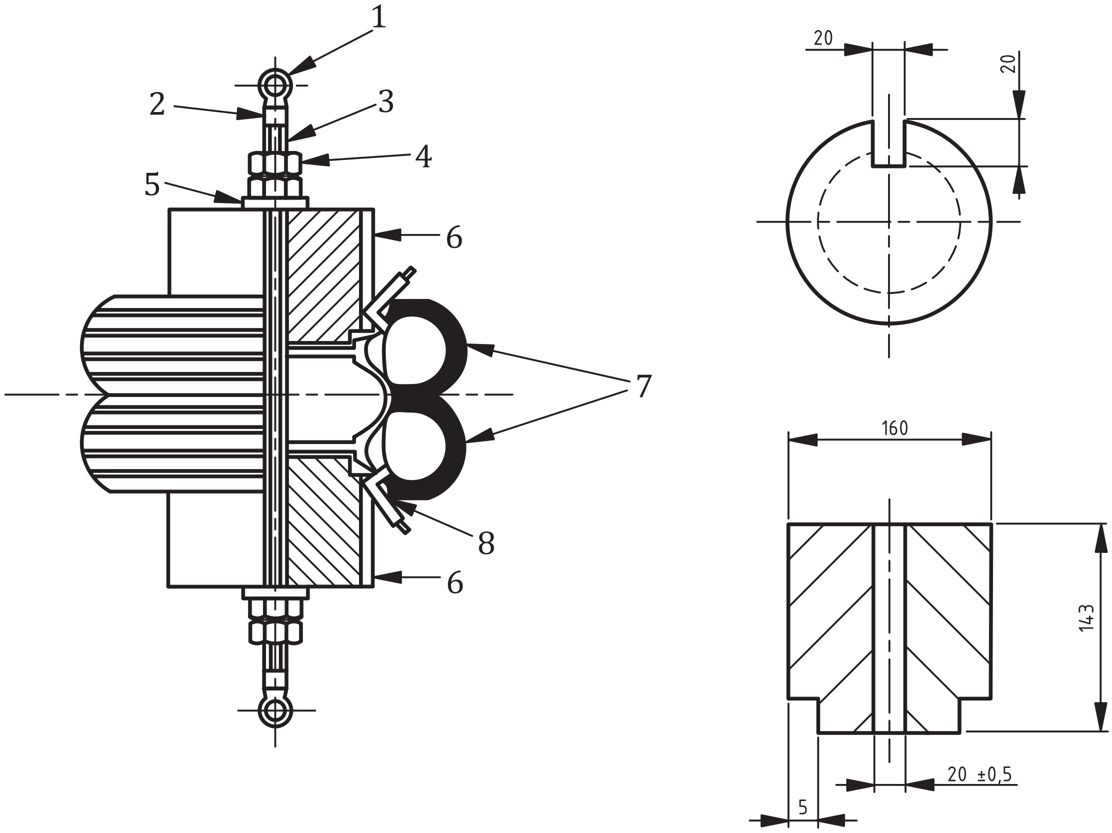
Check the air pressure in the tyres in accordance with 5.4.3.

Remove all glass particles embedded in the surface of the tyres.

Inspect the state of the tyres regularly and replace when required.

3) Tyre 3.50-8/4PR (reference V47, V60, and V64) and Continental T7 are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

Dimensions in millimetres



a) plan   b) details of the mass

Key

		No. required	Remarks
1	eye bolt	2	M20
2	hexagonal nut	2	M20
3	screw spindle	1	M20 45 mm
4	hexagonal nut	4	M20
5	collar	4	
6	mass of density 7 830 kg/m^3	2	See Figure 8 b)
7	pneumatic tyre	2	Tyre 3.50–8/4PR[2)]
8	rim	2	250 – 8

Figure 8 — The twin tyre impactor

5.1.4 Suspension device.

The impactor shall be suspended by means of a steel cable of diameter 5 mm conforming to ISO 2408, from a bracket attached above the head of the main frame. The bracket shall be rigid to ensure that the point of suspension remains stationary during the test and shall be positioned to permit the impactor to strike the centre of the test piece.

At the highest drop height, the angle, θ, between the taut suspension cable and the bracket shall not be less than 14° (see Figure 3).

When the impactor is hanging freely, at rest, the distance between the impactor and the surface of the test piece, d, shall not exceed 15 mm and shall not be less than 5 mm (see Figure 3) and the centre of area of contact of the impactor shall be within 50 mm vertically and horizontally from the centre of the test piece.

5.1.5 Traction and release system.

The impactor release mechanism enables the impactor to be raised and positioned at each of the specified drop height positions, and then to be released so that it swings freely and impacts the test piece. The release cable shall be connected to the top and bottom ends of the impactor by suitable links so that the raising force is applied at right angles to the axis of the impactor. The release mechanism shall ensure that the release cable is maintained at the correct orientation at each of the drop heights. An example of a release mechanism is given in Annex F.

5.2 Calibration of test apparatus

The test apparatus shall be calibrated in accordance with Annex B, in order to ensure that the energy transferred to the test piece by the impactor during the test carried out on different apparatus is consistent.

5.3 Test pieces

5.3.1 General

Each test piece shall comprise a single pane of glass product and be representative of the normal production of the type of product submitted for test.

5.3.2 Dimensions of the test pieces

The test pieces shall have the following dimensions:

a) width: (876 ± 2) mm;

b) height: (1 938 ± 2) mm.

Results obtained with test pieces of these dimensions are valid for classification purposes of the glass product whatever the service dimensions.

5.3.3 Number of test pieces

The test shall be carried out at each drop height on four pieces of identical structure and the same nominal thickness.

If the test pieces are of an asymmetric material, their number shall be doubled unless they are intended solely for installation in situations where the risk of impact is from one side only.

5.3.4 Preparation of the test pieces

Remove all masking and protection material from the test pieces and condition for a minimum of 12 h at (20 ± 5) °C.

5.4 Impact test procedure

5.4.1 Testing shall start at the lowest drop height (see Table 1) and increase up to the drop height appropriate to the class for which the material is intended (see 6.2).

5.4.2 The test shall be carried out at (20 ± 5) °C, i.e. room temperature.

5.4.3 Place each test piece in the clamping frame so that its edges are encased in the rubber to a minimum depth of 10 mm. The test piece shall be firmly clamped within the sub-frame.

Use either a twin tyre impactor or shot bag impactor. When using the twin tyre impactor, inflate both impactor tyres to a pressure of (0,35 ± 0,02) MPa. Pressure shall be checked prior to testing and every 4 h after the start of the test.

Raise the impactor to the lowest drop height (see Table 1) and stabilize. At the drop height, the suspension cable shall be taut, and the axis of the impactor and cable shall be in line (see Figure 3).

Table 1 — Impact levels

Classification	Lead shot bag mm	Twin tyre mm
3	300	190
2	450	450
1	1 200	1 200

5.4.4 Release the impactor so that it falls with a pendular movement and without initial velocity. The direction of impact on the centre of the test piece shall be normal to the surface. If the impactor strikes the test piece more than once the test shall be deemed to be invalid.

Use either a twin tyre impactor or shot bag impactor. When using a twin tyre impactor, its masses shall not make contact with the test piece during the impact.

5.4.5 For asymmetric materials that are intended for installation where the risk of impact is from both sides, carry out the test on both sides.

For asymmetric materials where the required classification is for one face only, solely the designated face shall be tested and this shall be reported in the test report.

5.4.6 Inspect the test piece after impact and note whether

a) it remains unbroken,

b) it broke in accordance with either the requirements of 4.2 or 4.3 or

c) it broke and failed to conform to the requirements of 4.2 or 4.3.

5.4.7 If any of the initial four test pieces fails to conform to the requirements of 4.2 or 4.3, terminate the procedure. If all four test pieces either do not break or else break according to the criteria given in 4.2 or 4.3, and it is required by manufacturer to test the material to a higher impact level, increase the drop height to the next level (see Table 1). Repeat the test on four more samples of the same material.

If the material remained unbroken, the same sample(s) may be used.

5.4.8 Report all test results in accordance with Clause 7.

6 Classification

6.1 General

Glass conforming to this International Standard is classified in accordance with the following:

a) its performance under the impact test;

b) the drop height at which breakage occurred;

c) the drop height at which the product satisfied the specifications of 4.2;

d) the drop height at which the product satisfied the specifications of 4.3.

6.2 Drop height class

Glass shall be classified as follows:

a) Class 3 — Material that conforms to the requirements of 4.2 or 4.3 when tested by the method given in 5.4 at a drop height of 190 mm with the double tyre impactor or 300 mm with the lead shot bag;

b) Class 2 — Material that conforms to the requirements of 4.2 or 4.3 when tested by the method given in 5.4 at drop heights of 190 mm with the double tyre impactor or 300 mm with the lead shot bag and 450 mm with both impactors;

c) Class 1 — Material that conforms to the requirements of 4.2 or 4.3 when tested by the method given in 5.4 at drop heights of 190 mm with the double tyre impactor or 300 mm with the lead shot bag, 450 mm with both impactors and 1 200 mm with both impactors.

6.3 Mode of breakage

If all test pieces remain unbroken at the drop height appropriate to its intended drop height class, the mode of breakage shall be determined as per Annex E. The mode of breakage shall be described as follows.

a) Type A — Numerous cracks appear forming separate fragments with sharp edges, some of which are large.

b) Type B — Numerous cracks appear, but the fragments hold together and do not separate.

c) Type C — Disintegration occurs, leading to a large number of small particles which are relatively harmless.

NOTE The descriptions of the mode of breakage are intended to convey the following information (see Annex E):

— Type A — mode of breakage typical of annealed glass;

— Type B — mode of breakage typical of laminated glass and wired glass;

— Type C — mode of breakage typical of toughened glass.

6.4 Performance classification

The performance classification of a glass product shall be given as follows:

$$\alpha(\beta)\varphi$$

where

α is the highest drop height class (6.2) at which the product either did not break or broke in accordance with 4.2 or 4.3;

β is the mode of breakage;

φ is the highest drop height class (6.2) at which the product either did not break or when it did break, broke in accordance with 4.2.

The retention criterion, φ, is met when no break occurs or numerous cracks appear, but no shear or opening is allowed within the test piece through which a (76 ± 1) mm diameter sphere can pass when a maximum force of 25 N is applied in accordance with Annex C.

When a glass product breaks at a drop height of 190 mm with a double tyre impactor or 300 mm with a lead shot bag and the breakage is not in accordance with 4.2, then the value of φ quoted shall be zero.

EXAMPLE 1 A set of laminated glass test pieces were impacted with the following results:

— at 190 mm/300 mm: three test pieces did not break while one test piece broke in accordance with 4.2;

— at 450 mm: all four test pieces broke in accordance with 4.2;

— at 1 200 mm: all four test pieces broke and failed to comply with 4.2 or 4.3.

Classification: 2(B)2

EXAMPLE 2 A set of thermally toughened soda lime silicate glass test pieces were impacted with the following results:

— at 190 mm/300 mm: all four test pieces did not break;

— at 450 mm: all four test pieces broke in accordance with 4.3;

— at 1 200 mm: all four test pieces broke in accordance with 4.3.

Classification: 1(C)3

EXAMPLE 3 A set of thermally toughened soda lime silicate glass test pieces were impacted with the following results:

— at 190 mm/300 mm: two test pieces did not break and two test pieces broke in accordance with 4.3;

— at 450 mm: all four test pieces broke in accordance with 4.3;

— at 1 200 mm: all four test pieces broke in accordance with 4.3.

Classification: 1(C)0

7 Test report

The test report shall contain at least the following information:

a) the type and nominal thickness of the glass product;

b) the dimensions of test pieces;

c) the test method and type of impactor used (twin tyre or shot bag), with reference to this International Standard, i.e. ISO 29584:2015;

d) the behaviour at each drop height for each test piece, including whether the test piece broke;

e) if the test piece broke, the mode of breakage, and whether breakage was in accordance with the criteria of 4.2, 4.3 or neither;

f) the date of the last calibration of the test rig according to Annex B;

g) in the case of applied films, whether the film was clamped in the frame;

h) the name and the address of the testing laboratory;

i) the test identification to enable test data to be traced;

j) the date of test report;

k) the name of manufacturer, processor and supplier of the test material;

l) the declared description of the material tested (including product type, trade name or other means of identification);

m) in the case of asymmetric materials, the classification of both surfaces unless only one impact side has been tested, in which case the classification and the surface that was impacted shall be reported.

Annex A
(normative)

Method of fabrication of the shot bag impactor

A.1 Figure 7 shows all the materials required for fabricating a shot bag (also called leather bag) along with the respective dimensions. The dimensions indicated on the right of Figure 6 are those specified in this International Standard. The dimensions indicated on the left of Figure 6 are those required for fabricating a shot bag. A shot bag compliant with this International Standard can be fabricated by placing the upper double nut position at 90 mm from the top of the bag and the lower double nut position at 40 mm from the bottom of the bag.

A.2 Before starting, loosen the strap of the leather bag and remove the internal rubber bag.

A.3 At the hanging strap position of the bag, provide a hole with a knife in a size to allow a threaded metal rod of diameter 10 mm to pass through.

A.4 Install eye nut 1 and plain washer 2 together with nut 3 at about 90 mm from the upper end of the threaded metal rod to form a double nut (for locking) and fix them securely in place. Then install four nuts fastening them retrospectively. Next, install a spring washer 4 and a sleeve nut 5.

A.5 At 40 mm from the other end of the threaded metal rod 10, form a double nut using hexagonal nut 3 to fix the rod in place. Install a spring washer 4 and metal washer 11 and thrust the rod 10 through the centre of the bottom of the leather bag 8 from inside.

A.6 Install metal washer 11 and spring washer 4 on the threaded metal rod extruding out of the bottom of the leather bag, fasten with a hexagonal nut 3 forming a double nut in combination with an eye nut 1, and fix the rod in place. (For safety during testing, if the end of the threaded metal rod does not extrude from the eye nut due to any thickness error with the metal or spring washers, change the distance from the end from 40 mm to 45 mm and repeat steps A.5 and A.6.)

A.7 At the other end of the rod, install plain washer 2 and thrust the rod through the hanging strap. Install another plain washer 2, then, fasten with eye nut 1. (As in step A.6, if the end of the rod does not extrude through the eye nut, change the distance from the upper end from 90 mm to about 95 mm and redo steps A.3 and A.6.)

The five nuts above sleeve nut 5 and plain washer 2 are to hang the leather bag following the specified dimensions.

A.8 Fix the lace from the bottom up to about half of the total lacing length.

A.9 Place the leather bag (A.8), three rolls of tape, and hose clamp 6 on a spring balance, then fill the bag with lead shots until the mass of the total assembly reaches (45,0 ± 0,1) kg.

A.10 Fix the remaining lace, and fasten the sleeve nut section of the leather bag neck with hose clamp 6.

A.11 Hang the completed leather bag weighing (45,0 ± 0,1) kg with a rope from the ceiling or other elevated section.

A.12 Tape the leather bag to cover its entire surface using three rolls of the specified type of tape in diagonal, overlapping manner. Tape the neck section separately. (The "neck" refers to the section extending from the top of the bag to about 120 mm downward.)

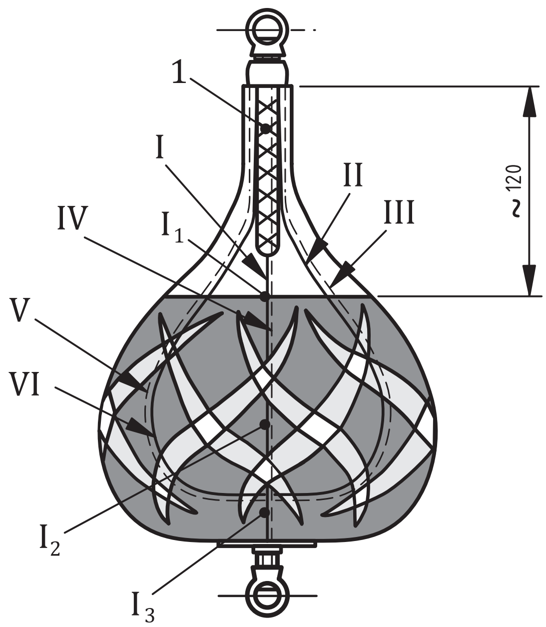
A.13 to A.26 describe the taping procedure.

A.13 Shape the lifted bag properly by tapping with the hand.

A.14 Measure the circumference of the section where the diameter is the maximum and calculate the diameter. The maximum diameter shall be about 250 mm. (If the maximum diameter significantly deviates from the specified value, there is no way to correct it. In that case, the only solution is probably to replace the bag with another one or remake the shot bag.)

A.15 Assign code I to the leather seam on which the lace is located. Assign codes II, III, IV, V and VI to the other seams counter clockwise from code I (see Figures A.1 and A.2).

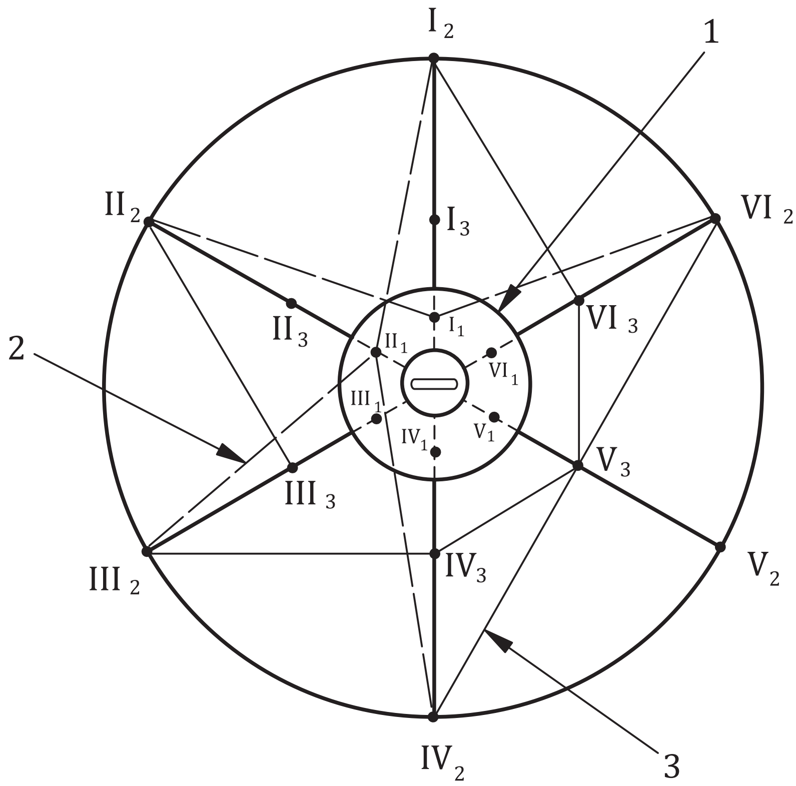
Dimensions in millimetres



Key

1	lace	V	seam 5 (at the back of the bag)
I	seam 1 (includes lace)	VI	seam 6
II	seam 2	I_1	taping point 1 on seam 1 (at base of neck portion, 30mm from lace portion)
III	seam 3 (at the back of the bag)	I_2	taping point 2 on seam 1 (at maximum circumference)
IV	seam 4 (at the back of the bag)	I_3	taping point 3 on seam 1 (30mm outside the metal washer)

Figure A.1 — Side elevation of shot bag (taping points are only shown on seam but they are on all seams)



Key

1	metal washer
2	example taping lines on upper part of bag
3	example taping lines on lower part of bag
I_1, II_1, III_1, IV_1, V_1, VI_1	upper taping points 1 (30 mm below lace) on seams I-VI
I_2, II_2, III_2, IV_2, V_2, VI_2	middle taping points 2 (at maximum circumference) on seams I-VI
I_3, II_3, III_3, IV_3, V_3, VI_3	lower taping points 3 (30 mm outside the metal washer) on seams I-VI

Figure A.2 — Plan of shot bag from below

A.16 As shown in Figures A.1 and A.2, assign code I_1 to the section about 30 mm below the lower end of the lace section, code I_2 to the section with the maximum diameter, code I_3 to the section about 30 mm outside the metal washer. In the same manner, assign code II_1, II_2, II_3, III_1, III_2, and III_3 and so on through VI_1, VI_2 and VI_3 in sequence.

A.17 Start taping at I_1 by applying it diagonally at an angle of 45° to reach point III_3 via point II_2. The tape should be lightly extended without any strain on it. Cut the tape at point III_3.

A.18 In the same manner, apply the tape lightly, without strain, to cover points II_1, III_2 and IV_3; III_1, IV_2 and V_3; IV_1, V_2 and VI_3; V_1, VI_2 and I_3; and VI_1, I_2 and II_3, cutting the tape at the end of each sequence.

A.19 Next, slant the tape by 45° in the opposite direction and tape the bag, covering I_1, VI_2 and V3; II_1, I_2 and VI_3; III_1, II_2 and I_3; IV_1, III_2 and II_3; V_1, IV_2 and III_3; and VI_1, V_2 and IV_3 in the same manner as in steps A.17 and A.18.

A.20 Around the tape applied (A.19), apply the tape in two rows on the right and left sides, completing twofold taping in total of five rows, also without strain.

Figure A.1 shows the view as taping is completed to this point. The sections shaded in darker grey are where the tape is applied in five rows and overlapped in four layers while the sections shaded in lighter grey where the tape is applied in twofold five rows.

(The total tape consumption up to this point amounts to 0,8 to 0,9 of a roll.)

The following are three tips on taping.

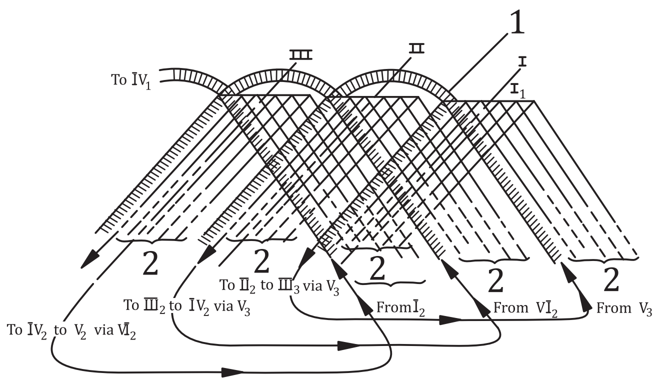
a) Avoid neighbouring rows overlapping when carrying out twofold taping in five rows. Overlapping causes wrinkles. In particular, the upper and lower sections of the respective rows can easily overlap. If this happens, tape locations cannot be correctly recognized in the subsequent steps.

b) Do allow the tape to be put under strain. Strain hardens the bag.

c) Ensure that tapes cross at the section where the diameter is greatest.

A.21 Next, shift the tape by half its width and apply it continuously, without cutting it, to achieve twofold taping in five rows. Start at point I_1 to pass through points II_2, III_3, IV_3, V_3, VI_2, I_1, in this order (see Figure A.2). Force the tape to be redirected at the bottom of the bag to apply it from point III_3 to point V_3 via IV_3. (Wrinkles are permitted in doing so.) Then, turn the taping direction to allow taping from point V_3 to point I_1 via point VI_2 (see Figure A.3).

A.22 From point I_1 where taping ended in the previous step, extend it (wrinkles permitted) to pass through II_1, III_2, IV_3, V_3, VI_3, I_2 and II_1 (see Figure A.3). In the same manner, apply the tape to cover III_1, IV_2, V_3, VI_3, I_3, II_2 and III_1; IV_1, V_2, VI_3, I_3, II_3, III_2 and IV_1; V_1, VI_2, I_3, II_3, III_3, IV_2 and V_1; VI_1, I_2, II_3, III_3, IV_3, V_2 and VI_1, then return to I_1. Then repeat the same procedure again to achieve twofold taping (see Figure A.3).



Key

1 starting point (shift the tape by half a width)

2 five rows twofold

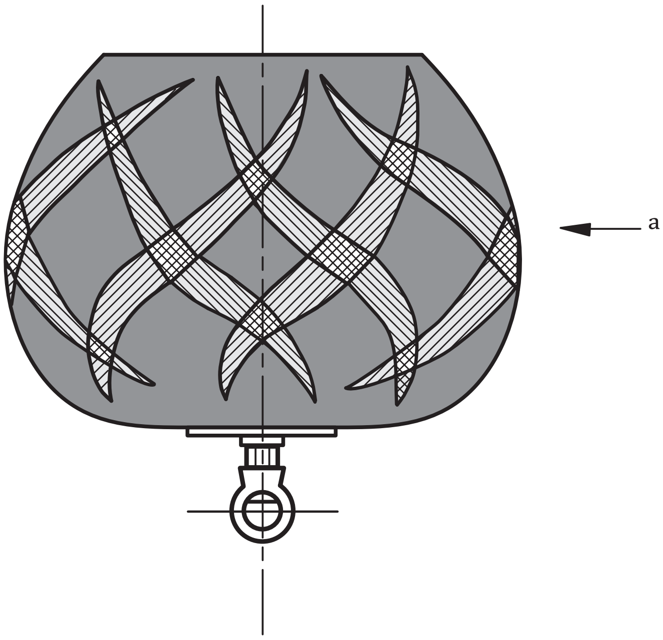
Figure A.3 — Taping method

A.23 As step A.22 is completed, the tape returns to point I_1. Next, shift the tape to the right, and follow steps A.21 and A.22 to perform the same procedure and achieve twofold taping in five rows. (Never strain the tape and apply it carefully in five rows.)

When the steps above are completed, taping is completed in eight folds in five rows over the sections shaded darkly in Figure A.1 and in the lighter-shaded sections, in four folds in five rows. (The total tape consumption up to this point amounts to 1,8 to 1,9 rolls.)

A.24 Reinforce the sections shown in white and the light grey shaded areas in Figure A.4 so that taping is achieved in eight folds. To reinforce, apply the tape in four folds and in several rows so that it crosses at the section where the diameter is the greatest. Now the tape is applied in eight folds over the white sections and light grey sections (see Figure A.4).

(The total tape consumption up to this point amounts to 2,6 to 2,7 rolls.)



Key

a Applying the tape in four folds over the white and light grey sections achieves taping at the intersection in eight folds.

Figure A.4 — Taping reinforcement

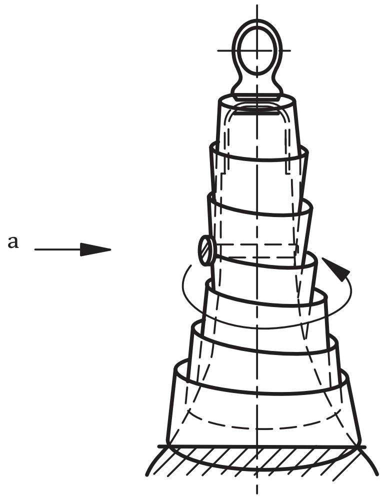
A.25 As it is specified that the body and neck sections be taped separately, start taping for the neck portion below the upper eye nut to proceed in a spiral manner downward by shifting the tape by half its width until the tape reaches the lace section. (Apply taping until the tape becomes flush with the point already taped in the previous steps up to step A.24.) The “neck” refers to the portion extending from the top of the bag to about 120 mm below (see Figure A.1).

Taping in a spiral manner causes part of the tape to be not in contact with the bag as shown in Figure A.5. Apply pressure to these parts of the tape so that contact with the bag is established.

Repeat this operation four times to achieve taping in eight folds.

(The total tape consumption up to this point amounts to about 2,9 rolls.)

A.26 As this Annex specifies that taping be performed using three rolls of tape, apply the remaining portion of the tape at random points with allowance given for retention of the tape used for reinforcement so that the tape is evenly applied.



Key

a Apply the tape in a spiral manner overlapping by half its width.

Figure A.5 — Taping impactor neck (view when taping is completed around the neck)

Annex B
(normative)

Calibration of the test rig

B.1 Calibration procedure

B.1.1 The calibration test piece shall be a 10 mm thick pane of thermally toughened soda lime silicate safety glass according to ISO 16293-1[4] made from soda lime silicate float glass.

The dimensions of the calibration test piece shall be (876 ± 2) mm × (1 938 ± 2) mm.

Remove all masking and protection material from the calibration test piece and condition it for a minimum of 12 h at the calibration temperature of (20 ± 5) °C.

Fix a constantan rosette strain gauge to the centre of the pane in order to measure the horizontal and vertical micro-deformation. The precision strain gauge[4)] shall be of the following type:

a) resistance at 24 °C: (350,00 ± 1,75) Ω or (120,0 ± 0,6) Ω;

b) length of the grid: 3,18 mm to 5 mm;

c) width of the grid: 1,4 mm to 4,57 mm.

B.1.2 Place the calibration test piece in the clamping frame so that the strain gauge is on the opposite side to the impact. When clamped, the rubber shall be compressed by not less than 5 % and not more than 10 % of the thickness.

Use either a twin tyre impactor or shot bag impactor.

When using a twin tyre impactor, inflate both tyres to a pressure of (0,35 ± 0,02) MPa.

Raise the impactor to the lowest drop height and stabilize. At the drop height, the suspension cable shall be taut and the axis of the impactor and cable shall be in line.

B.1.3 Release the impactor, stabilized in the launch position, so that it falls with a pendular movement without initial velocity. The impact shall occur at the centre of the calibration test piece striking it only once.

Measure and record the horizontal and vertical micro-deformation. Record three measurements per drop height.

B.1.4 Repeat the procedure in B.1.3 for each drop height (see Table B.1).

4) The CEA-06-125WT-350 is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

Table B.1 — Drop heights for the calibration test

Drop height mm
200
250
300
450
700
1 000
1 200

B.2 Calibration report

The calibration report shall contain at least the following information:

a) the name, address and reference to impact rig;

b) the name of test engineer, date of calibration;

c) the type and nominal thickness of glass;

d) the dimensions of the calibration test piece;

e) the type of impactor;

f) the description of the test rig (material e.g. steel, etc.; type of clamping, i.e. continuous, bolted, etc.);

g) all measured values per drop height;

h) the curves (drop height versus horizontal micro-deformation and drop height versus vertical micro-deformation) based upon the mean values with the type of strain gauge used;

i) the test method used, with reference to this Annex of this International Standard, i.e. ISO 29584:2015, Annex B.

B.3 Reference calibration curve

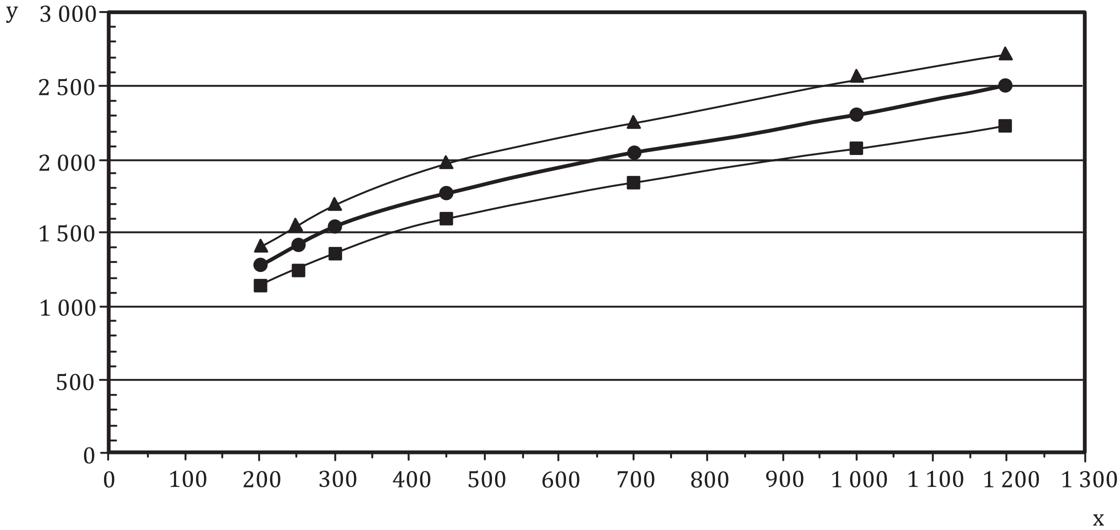
The curves obtained after the calibration procedure shall be in accordance with the reference calibration curves within a tolerance of ±10 % (see Tables B.2 and B.3 and Figures B.1 and B.2 for a twin tyre impactor and Tables B.4 and B.5 and Figures B.3 and B.4 for a lead shot bag, respectively) in order to ensure that the energy transferred to the test piece by the impactor during the test is equivalent to the energy required for the classification.

B.4 Calibration frequency

The calibration procedure shall be undertaken every three years. However, if a major change, e.g. change of structural components, clamping system, etc., is made to the rig, then it shall be recalibrated prior to testing.

Table B.2 — Reference mean peak horizontal micro-strain for twin tyre impactor

Drop height mm	Mean value $\varepsilon_{TT,h} \times 10^6$	Mean value– minus 10 %	Mean value– plus 10 %
200	1 275	1 147	1 402
250	1 418	1 276	1 559
300	1 542	1 388	1 696
450	1 793	1 613	1 972
700	2 063	1 857	2 269
1 000	2 327	2 094	2 559
1 200	2 503	2 252	2 753



Key

- mean value
- mean value minus 10 %
- mean value plus 10 %

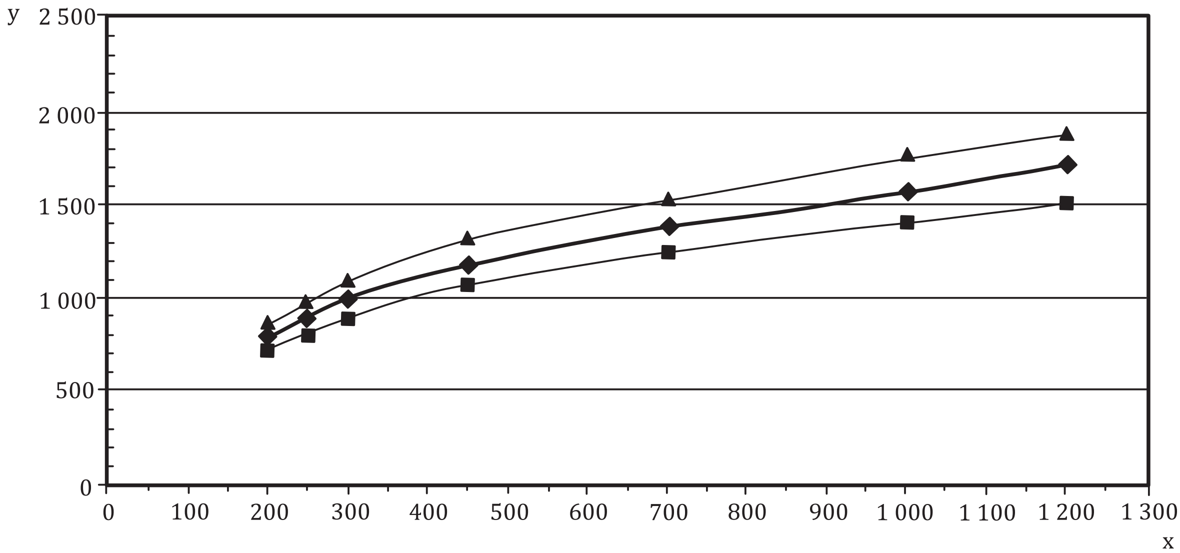
x drop height

y mean peak horizontal micro-strain for twin tyre impactor ($\varepsilon_{TT,h} \times 10^6$)

Figure B.1 — Reference horizontal micro-strain calibration curve for twin tyre impactor

Table B.3 — Reference mean peak vertical micro-strain for twin tyre impactor

Drop height mm	Mean value $\varepsilon_{TT,v} \times 10^6$	Mean value– minus 10 %	Mean value– plus 10 %
200	805	724	885
250	911	820	1 002
300	1 013	912	1 114
450	1 181	1 063	1 299
700	1 389	1 250	1 528
1 000	1 601	1 440	1 761
1 200	1 742	1 567	1 916



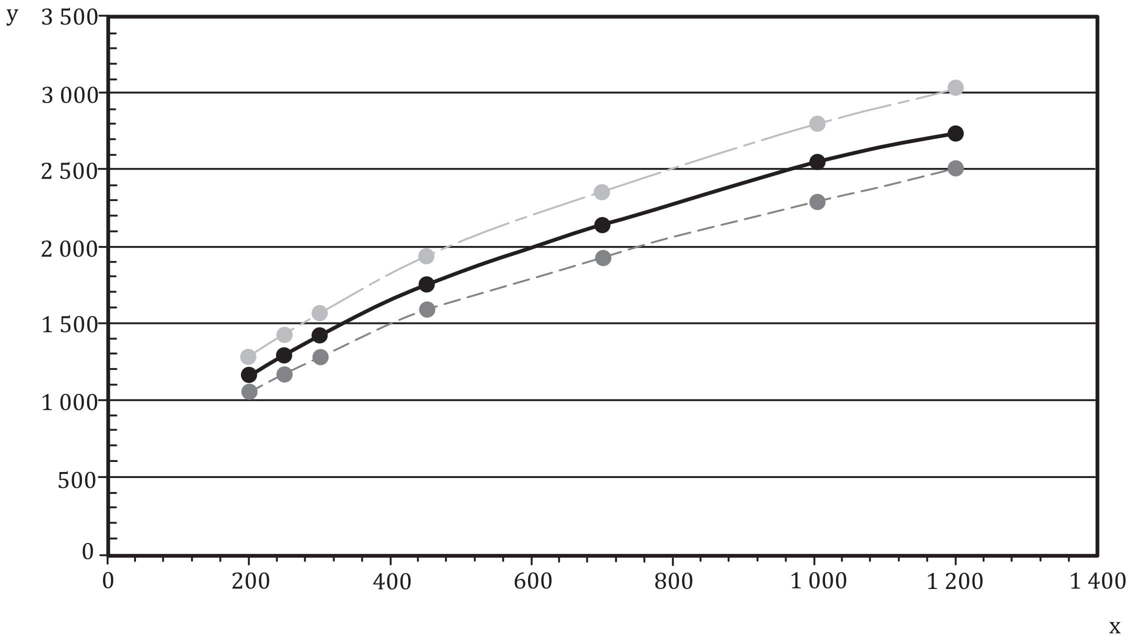
Key

◆	mean value
■	mean value minus 10 %
▲	mean value plus 10 %
x	drop height, *h*
y	mean peak vertical micro-strain for twin tyre impactor ($\varepsilon_{TT,\,v} \times 10^6$)

Figure B.2 — Reference vertical micro-strain calibration curve for twin tyre impactor

Table B.4 — Reference mean peak horizontal micro-strain for shot bag impactor

Drop height mm	**Mean value** $\varepsilon_{SB,\,h} \times 10^6$	**Mean value–minus 10 %**	**Mean value–plus 10 %**
200	1 174	1 057	1 291
250	1 298	1 169	1 428
300	1 434	1 290	1 577
450	1 762	1 586	1 939
700	2 159	1 943	2 375
1 000	2 567	2 311	2 824
1 200	2 764	2 487	3 040



Key

- mean value
- mean value minus 10 %
- mean value plus 10 %

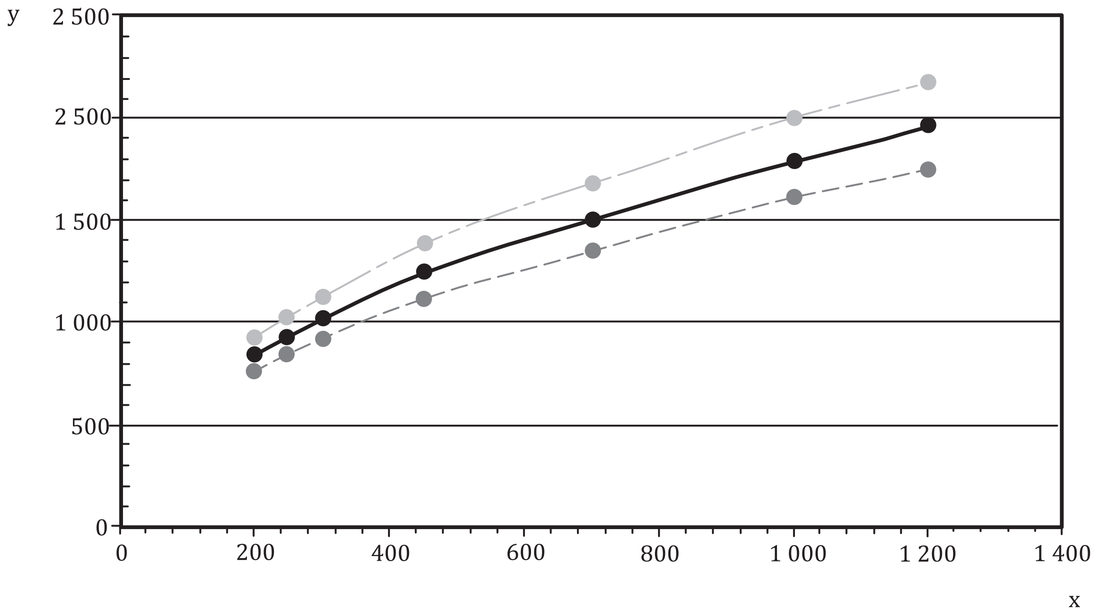
x drop height, *h*

y mean peak horizontal micro-strain for shot bag impactor ($\varepsilon_{SB,\,h} \times 10^6$)

Figure B.3 — Reference horizontal micro-strain calibration curve for shot bag impactor

Table B.5 — Reference mean peak vertical micro-strain for shot bag impactor

Drop height mm	Mean value $\varepsilon_{SB,\,v} \times 10^6$	Mean value– minus 10 %	Mean value– plus 10 %
200	843	759	928
250	943	849	1 038
300	1 029	926	1 131
450	1 249	1 124	1 373
700	1 512	1 361	1 664
1 000	1 810	1 629	1 991
1 200	1 963	1 767	2 160



Key

- mean value
- mean value minus 10 %
- mean value plus 10 %

x drop height *h*

y mean peak vertical micro-strain for shot bag impactor ($\varepsilon_{SB,v} \times 10^6$)

Figure B.4 — Reference vertical micro-strain calibration curve for shot bag impactor

Annex C
(normative)

Sphere penetration test

C.1 Probe assembly

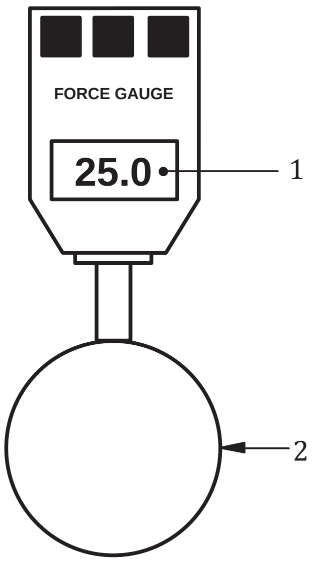
The probe assembly shall consist of a sphere[5)] of diameter (76 ± 1) mm connected to an arm with a device[6)] for measuring when a maximum force of 25 N has been applied. An example of a probe assembly is shown in Figure C.1.

C.2 Operation

The probe assembly shall be held so that it is horizontal. It shall then be pushed into any opening formed in the test piece. The weakest point of resistance shall be selected. A horizontal force shall be applied until either

a) a maximum force of 25 N has been achieved without penetration by the sphere (the test piece shall be deemed to have passed the test) or

b) the maximum diameter of the sphere has passed through the plane of the test piece without a force of 25 N being achieved (the test piece shall be deemed to have failed the test).



Key

1 force indicated in Newtons

2 76 mm diameter sphere

Figure C.1 — Example of a probe to verify free passage of a 76 mm diameter sphere

5) A sphere available from Euromatic is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

6) The portable force indicator, model PF1-200N, is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

Annex D
(informative)

Example of a test rig

See Figures D.1 to D.3.

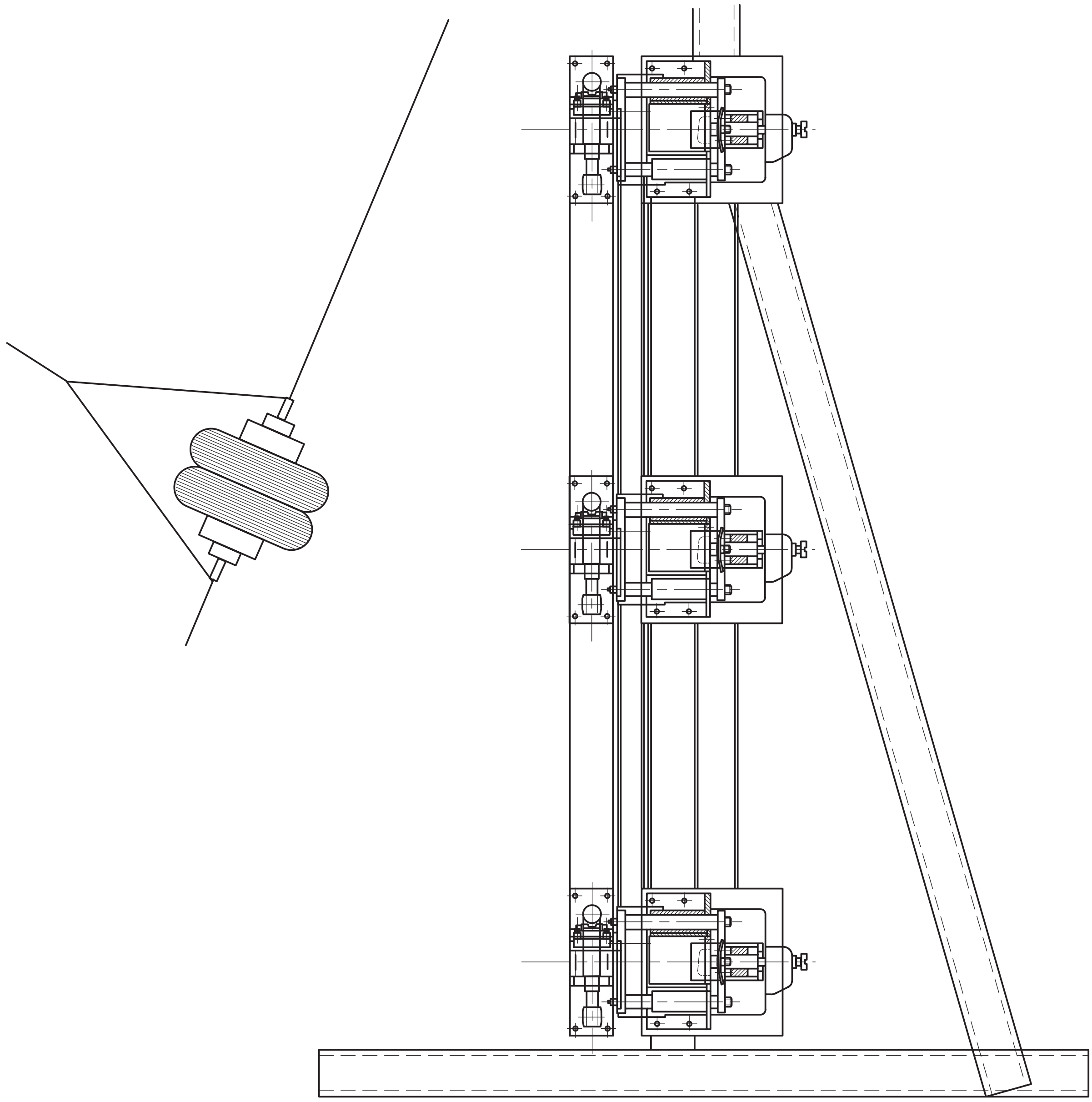
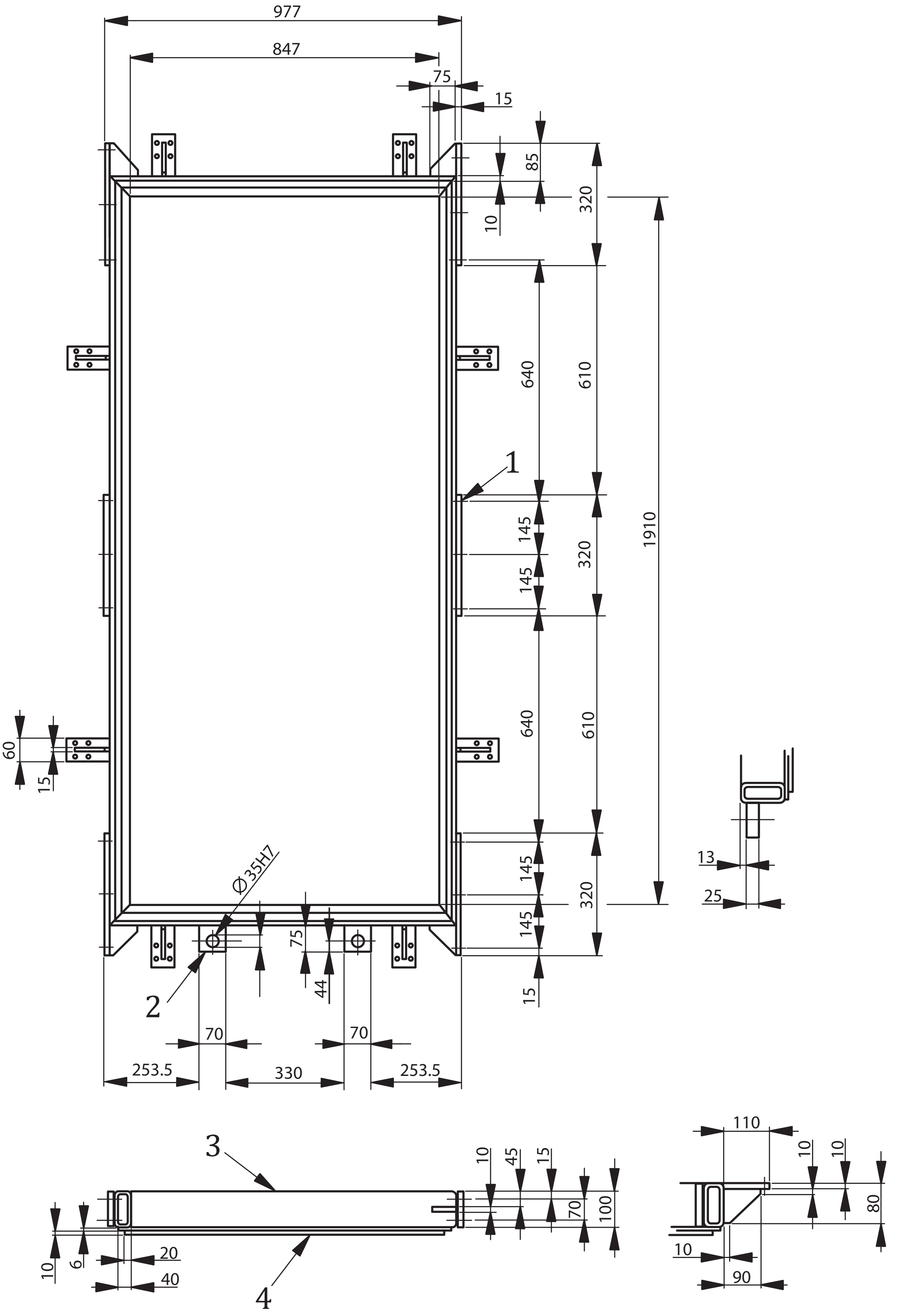


Figure D.1 — Side elevation of the main frame with the impactor

Dimensions in millimetres

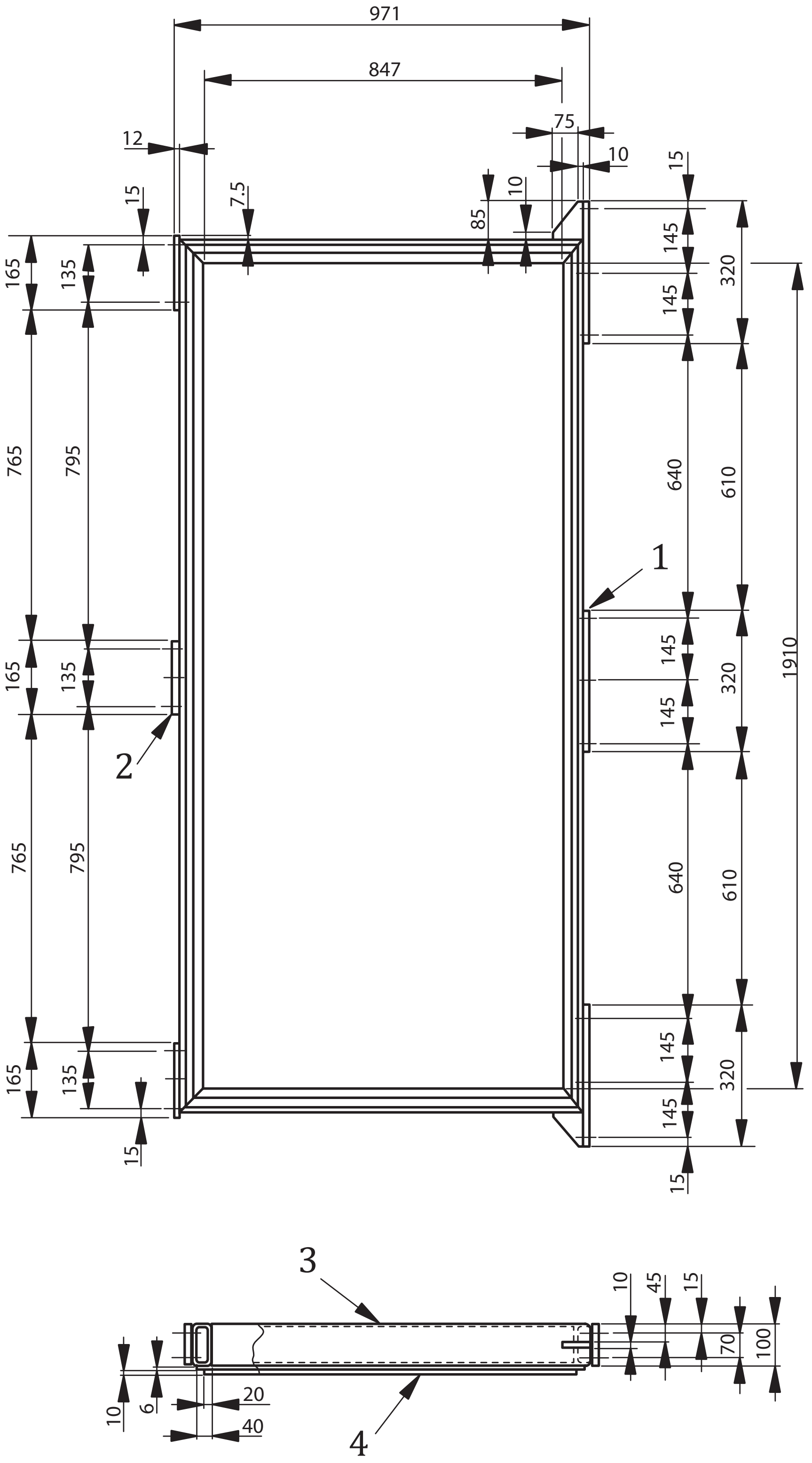


Key

1	12 holes ⌀ M12	3	100 × 50 × 8 right hand side
2	see detail	4	rubber strips 20 × 10

Figure D.2 — Component No. 1

Dimensions in millimetres



Key

1 18 holes ⌀ M12

2 12 holes ⌀ M12

3 100 × 50 × 8 right hand side

4 rubber strips 20 × 10

Figure D.3 — Component No. 2

Annex E
(informative)

Terms and definitions of glass types

E.1

annealed glass

glass, with no restriction on composition, that has been subjected to controlled cooling to reduce the presence of residual stress in the glass thus allowing easy cutting

EXAMPLES Float glass, sheet glass, patterned glass and wired glass.

Note 1 to entry If annealed glass is broken and penetrated the resulting glass edges are sharp and capable of producing piercing injuries. Breakage typical of type A.

E.2

thermally toughened soda lime silicate safety glass

glass within which a permanent surface compressive stress has been induced by a controlled heating and cooling process in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics

Note 1 to entry Thermally toughened glass is difficult to penetrate, but if broken it fragments into small relatively harmless pieces. Breakage typical of type C.

E.3

heat-strengthened soda lime silicate glass

glass within which a permanent surface compressive stress has been induced by a controlled heating and cooling process in order to give it increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics

Note 1 to entry When penetrated, heat-strengthened glass breaks like annealed glass. Breakage typical of type A.

E.4

chemically strengthened soda lime silicate glass

glass made by subjecting a soda lime silica glass to an ion exchange process in order to give it increased resistance to mechanical and thermal stress

Note 1 to entry The smaller diameter ions in the glass surface and edges are replaced with larger ones, which results in the glass surface and edges being placed in compression.

Note 2 to entry When penetrated, chemically strengthened glass breaks like annealed glass. Breakage typical of type A.

E.5

laminated safety glass

assembly consisting of a sheet of glass and sheet(s) of glass or plastics joined by one or more interlayers where in the case of breakage the interlayer serves to retain the glass fragments, limits the size of opening, offers residual resistance and reduces the risk of cutting or piercing injuries

Note 1 to entry Adapted from ISO 12543-1:2011, 2.8.

Note 2 to entry See ISO 12543-2.

Note 3 to entry Breakage is typical of type B.

E.6

wired glass

soda lime silicate glass, having metal wires (e.g. spot-welded square mesh) introduced and completely embedded during rolling, the structure of which remains largely held together if the glass fractures (cast and polished)

[SOURCE: ISO 6345:1990, 6.8]

Note 1 to entry When wired glass is broken after impact, it is held together by the wires. However, if penetrated, the edges are sharp. Breakage typical of type B.

E.7

polished wired glass

flat translucent, clear or tinted soda lime silicate glass having parallel and polished faces obtained by grinding and polishing the faces of wired patterned glass

Note 1 to entry When wired glass is broken, after impact it is held together by the wires. However, if penetrated, the edges are sharp. Breakage typical of type B.

E.8

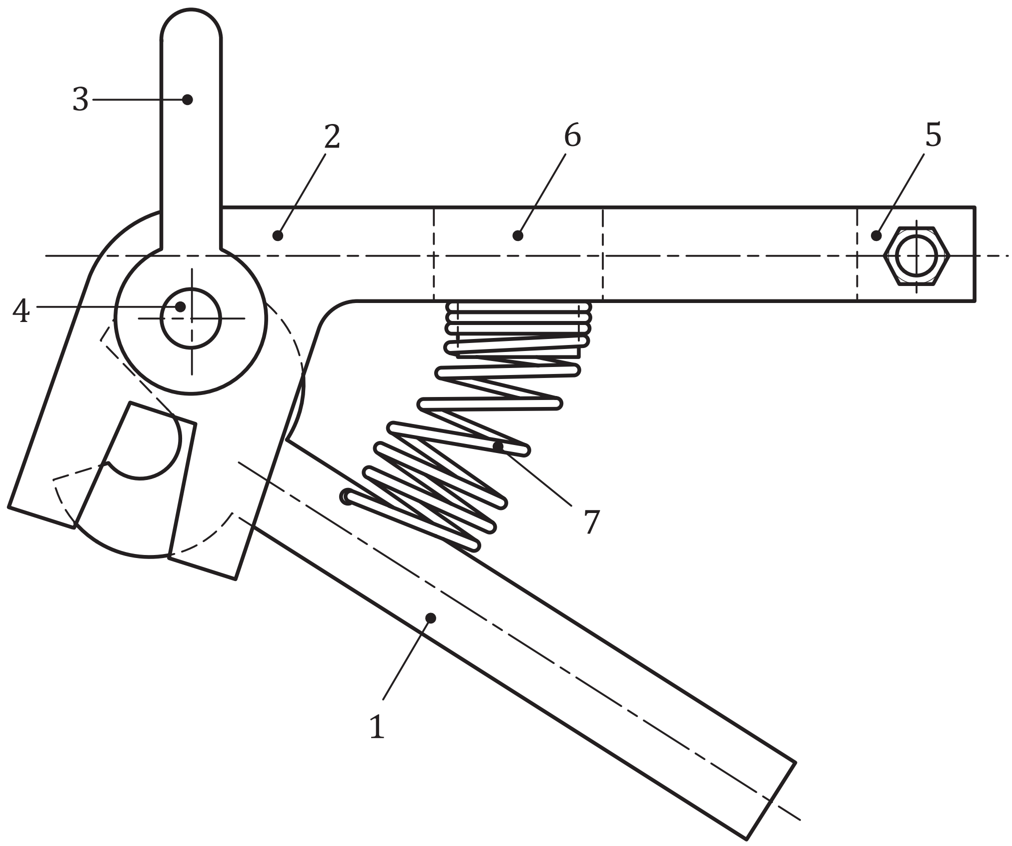
film-backed annealed glass

glass which has a flexible plastics film adhered to one surface

Note 1 to entry When broken, the film holds the glass pieces together. Breakage typical of type B.

Annex F
(informative)

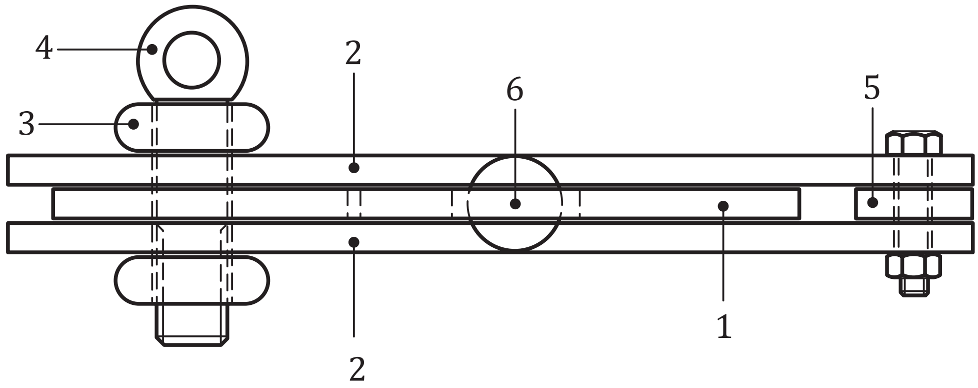
Example of release mechanism



Key

1	Component 1	5	Component 5
2	Component 2	6	Component 6
3	Component 3	7	Component 7
4	Component 4		

Figure F.1 — Example of release mechanism view 1



Key

1 Component 1
2 Component 2
3 Component 3
4 Component 4
5 Component 5
6 Component 6
7 Component 7

Figure F.2 — Example of release mechanism view 2

Dimensions in millimetres

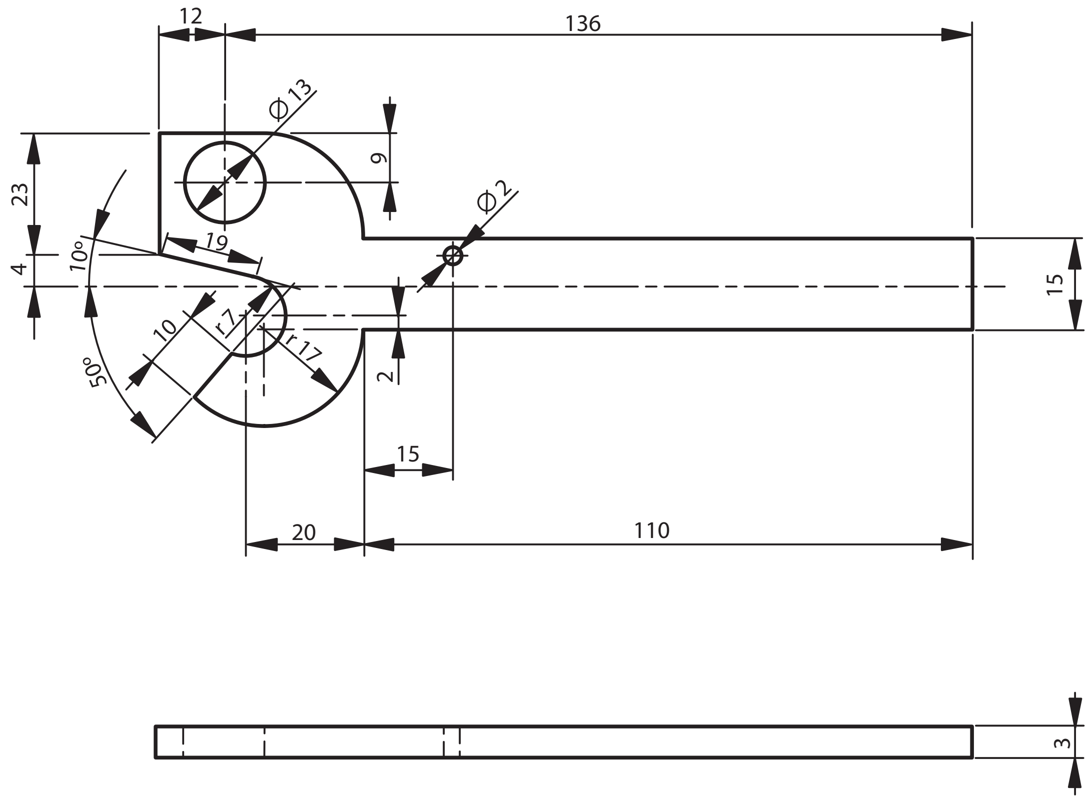


Figure F.3 — Component No.1

Dimensions in millimetres

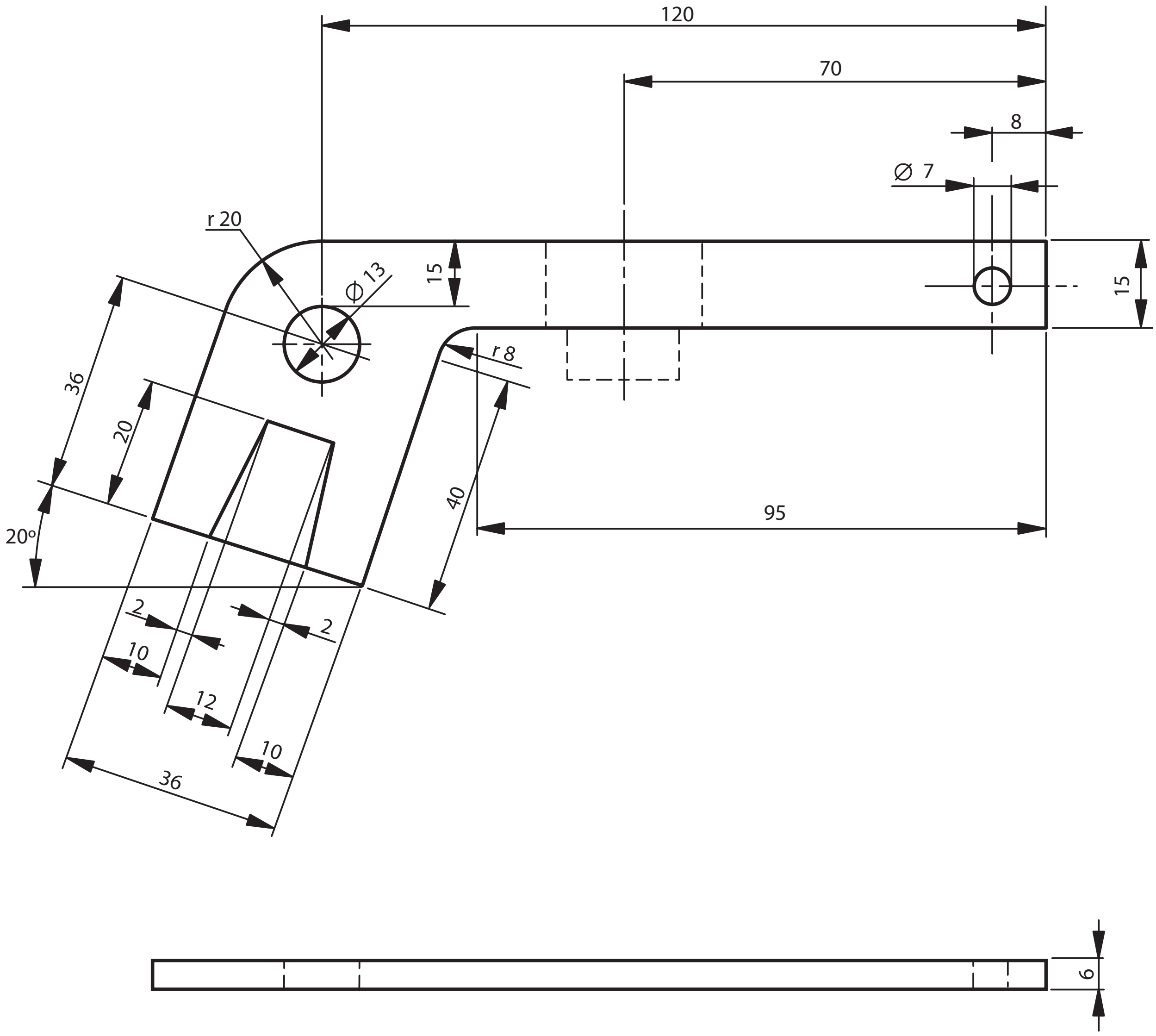


Figure F.4 — Component No.2

Dimensions in millimetres

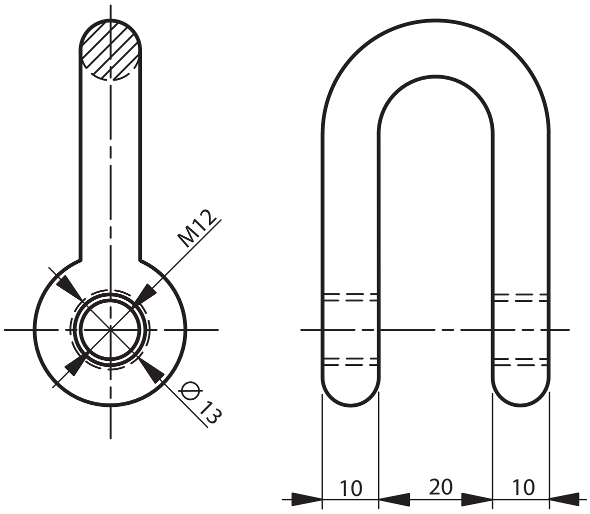


Figure F.5 — Component No.3

Dimensions in millimetres

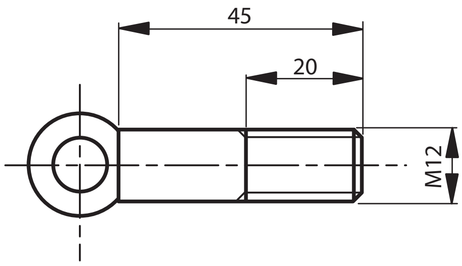


Figure F.6 — Component No.4

Dimensions in millimetres

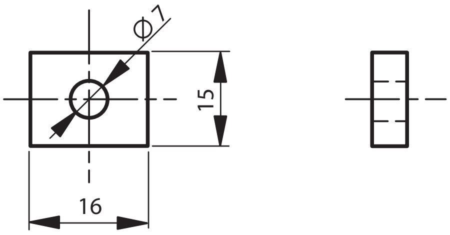


Figure F.7 — Component No.5

Dimensions in millimetres

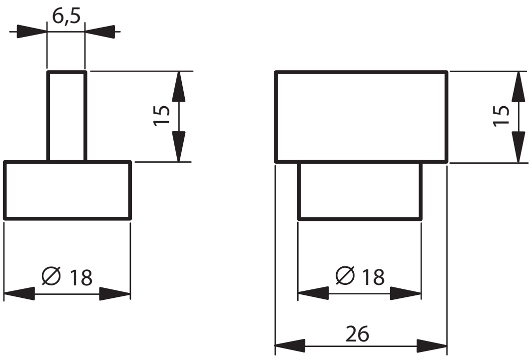


Figure F.8 — Component No.6

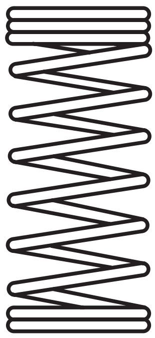


Figure F.9 — Component No.7

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