INTERNATIONAL STANDARD

ISO 16936-2

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Glass in building — Forced-entry security glazing —

Part 2: Test and classification by repetitive impact of a hammer and axe at room temperature

Verre dans la construction — Vitrages de sécurité contre infractions —

Partie 2: Essai et classification par impact répété d'un marteau et d'une hache à température ambiante

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 16936-2 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*.

ISO 16936 consists of the following parts, under the general title *Glass in building — Forced-entry security glazing*:

— *Part 1: Test and classification by repetitive ball drop*

— *Part 2: Test and classification by repetitive impact of a hammer and axe at room temperature*

— *Part 3: Test and classification by manual attack*

— *Part 4: Test and classification by pendulum impact under thermally and fire stressed conditions*

Introduction

This part of ISO 16936 assesses security-glazing products that are more familiarly known as “anti-vandal”, “anti-bandit” and “detention” glazing products. Because there is no single test that will cover the wide range of resistances to attack, four separate test methods are provided to assess the forced entry resistant properties of security glazing. It is not intended that any particular test method be associated with the terms “anti-vandal” or “anti-bandit”, since these terms can be only loosely defined and there is considerable overlap in their definition.

It is important that security glazing products be installed in a frame which can give appropriate resistance to impact and which also provides a suitable support for the security-glazing product. It is important that cutouts and holes in security glazing products be avoided where possible, as these can affect the resistance of the product.

The test method specified in this part of ISO 16936 does not reproduce the conditions of real human attack, but is intended to give a classification of comparative resistance of glazing.

Glass in building — Forced-entry security glazing —

Part 2:
Test and classification by repetitive impact of a hammer and axe at room temperature

1 Scope

This part of ISO 16936 specifies requirements and a mechanical test method for security glazing designed to resist actions of manual attack by delaying access of objects and/or persons to a protected space for a short period of time. This part of ISO 16936 classifies security glazing products into categories of resistance against repetitive impacts of a hammer and an axe.

In this part of ISO 16936, the categories of resistance have not been assigned to special applications. Glazing classification should be specified on an individual basis for every application.

This part of ISO 16936 deals with mechanical resistance to manual attack only. Other properties can also be important.

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 (including any amendments) applies.

ISO 48:1994, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

3 Terms and definitions

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

3.1
action of force
deliberate action on the part of a person made with the intention of creating a hole in the security glazing product, by the use of manually held implements or by the use of thrown objects

3.2
attack face
face of a test piece marked by the manufacturer and/or supplier that is designed to face the attack

3.3
category of resistance
classification of the capability of a security glazing product to resist actions of force

3.4
protected space
space protected against access by the completed installation

3.5
sample
specified number of test pieces which together are representative of the security glazing product intended to comply with a particular category of resistance in this part of ISO 16936

3.6
security glazing composition
specific construction of a glazing product

NOTE A product is deemed to be of the same or superior security glazing composition if individual plies are exchanged with others of a different colour, but without significant effect on the resistance to actions of force; and/or additional glazing products are installed on either face of the security glazing product, laminated to it or with an air space; and/or additional equipment such as alarm wires, heating wires, printing, or surface coatings (on part or all of the surface) are incorporated into the security glazing product, provided that this does not significantly affect the resistance to actions of force.

3.7
security glazing product
product based on glass with or without plastics with a single or multiple ply construction, where the individual plies are of uniform thickness over the whole area of the product

NOTE A security-glazing product is usually transparent or translucent, and provides a specific resistance to the actions of force.

3.8
test piece
specified piece of security glazing product submitted to a specified test procedure

4 Symbols (and abbreviated terms)

a_i	angle of impact, measured between the surface of the test piece and the handle; see Figure 4
E_i	impact energy of the hammer or axe
n_1, n_2	number of axe strikes
r_1	radius of the blade of the axe head
v_i	impact velocity of the hammer or axe
x	length of slit in the security glazing product formed by the axe blade

5 Sampling

The sample submitted for testing shall consist of three test pieces for each category of which testing is required.

To ensure against invalid test results because of errors during the test, it is advisable to submit at least one extra test piece.

Each test piece shall be (1 100 $\pm$ 5) mm long $\times$ (900 $\pm$ 5) mm wide. The edges shall be free from visible chips, cracks and flaws. Glass samples should be lightly arrissed for ease of handling.

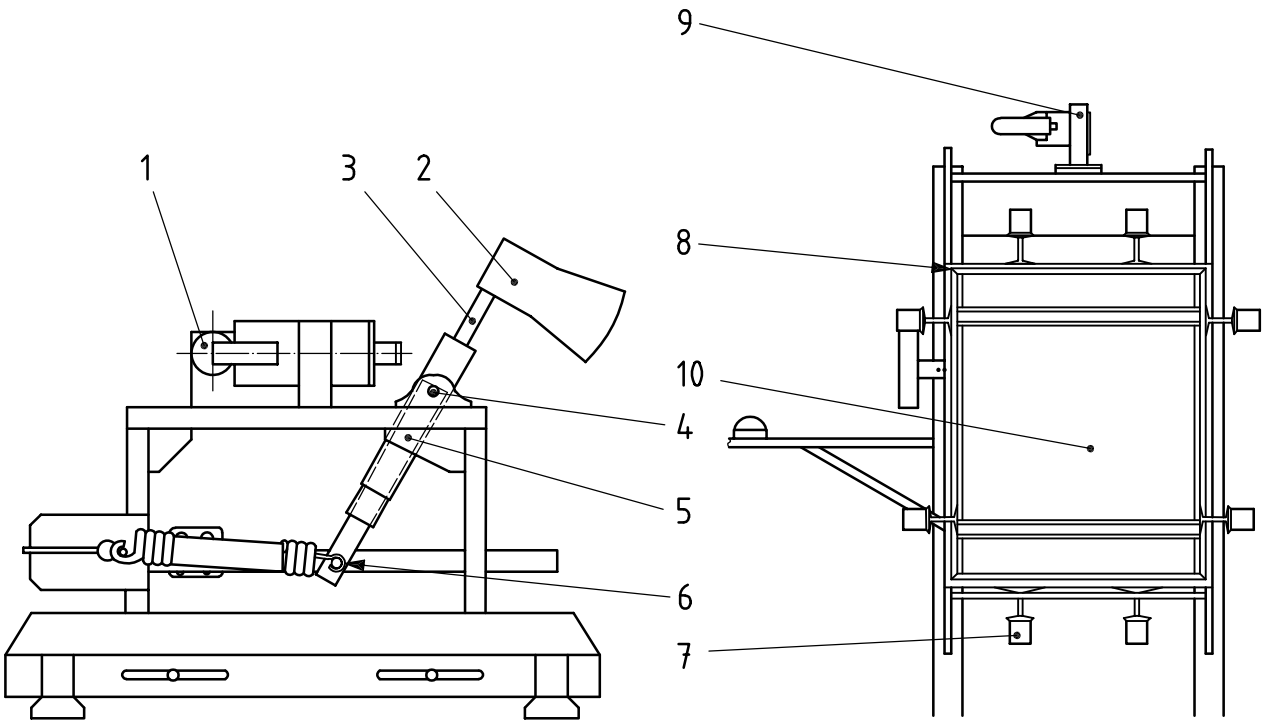
The surface to be impacted shall be marked on each test piece.

Each test piece shall be stored vertically and self-supporting at (18 $\pm$ 3) °C, for at least 12 h immediately prior to the test.

6 Apparatus

6.1 General

Figure 1 shows the general arrangement of the test piece and the mechanism for swinging the axe. A detailed specification of the component parts is given in 6.2 to 6.4.



Key

1 release mechanism
2 axe head
3 handle
4 axis of rotation
5 sleeve
6 tension spring
7 pneumatic clamp
8 clamping frame
9 height adjustor
10 test piece

Figure 1 — General view of axe test apparatus

6.2 Tool specifications

6.2.1 Axe head

The axe head shall have the form and dimensions in accordance with Figure 2.

Dimensions in millimetres

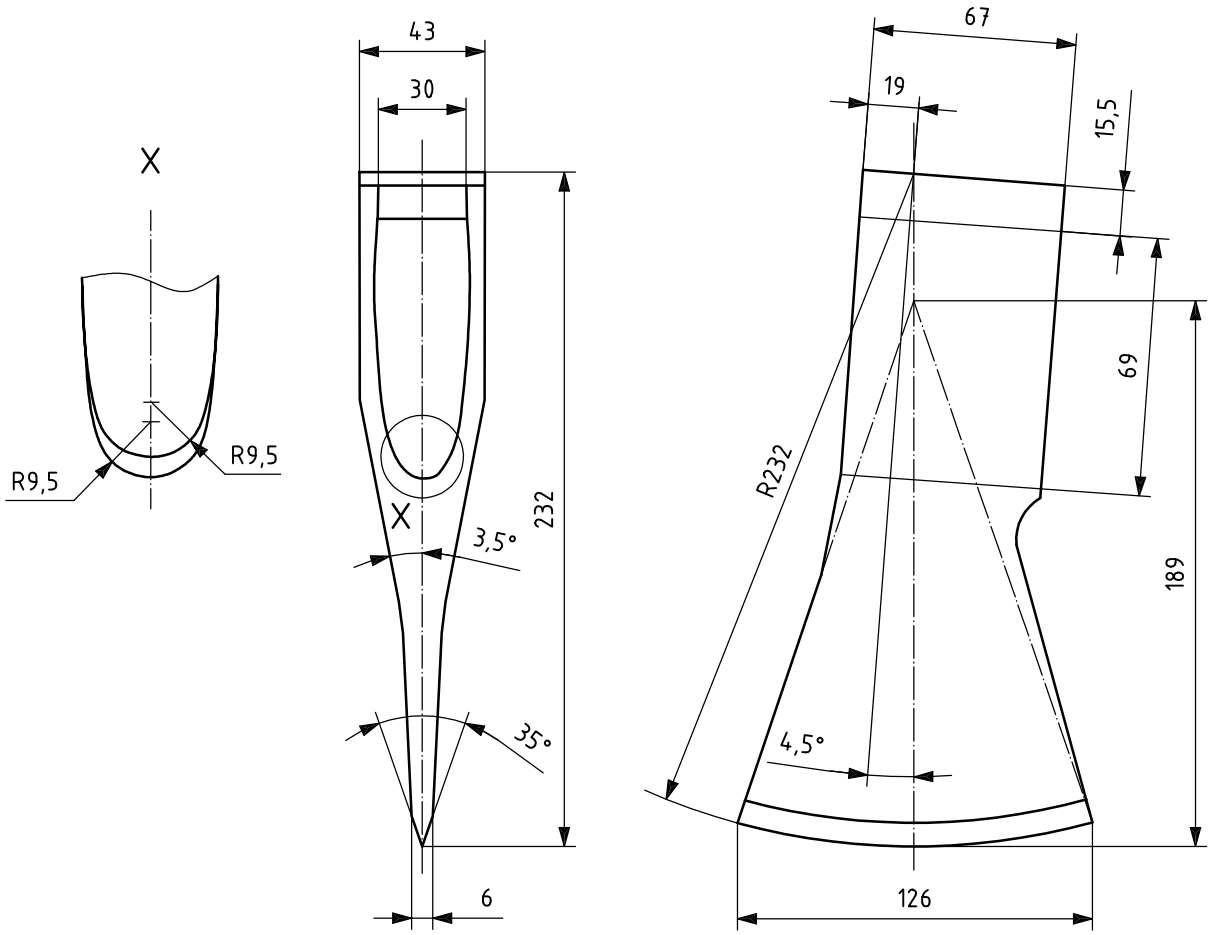


Figure 2 — Axe head

The axe head shall have a mass of (2,0 ± 0,1) kg and shall be made from wrought, unalloyed steel with a chemical composition as shown in Table 1.

Table 1 — Chemical composition of axe head

C min.	**Mn** min.	**Si** max.	**P** max.	**S** max.	**(P + S)** max.
0,6	0,6	0,5	0,03	0,03	0,05

The blade of the axe head shall be hardened to a distance of at least 30 mm from the edge.

At the beginning of the test, the blade of the axe head shall have a “qualified sharpness” as follows:

— a blade wedge angle of $(35 \pm 1)^{\circ}$;

— a slightly convex flank;

— a blade radius, r_1, of $232^{\ 0}_{-10}$ mm;

— a hardness of 51 HRC to 56 HRC in accordance with ISO 6508-1.

After every 10 impacts, the blade shall be re-sharpened.

An axe should not be re-used for testing, if

— the axe head was reduced during sharpening to a blade radius less than 222 mm,

— the hardness is no longer within 51 HRC to 56 HRC.

6.2.2 Hammer head

The head of the hammer is designed to simulate the blunt edge of an axe head and is used in place of the axe head. The hammer head shall be made from a steel bar of cross section (40 ± 2) mm square, length (232 ± 10) mm and of mass $(2{,}0 \pm 0{,}1)$ kg. The head shall have a hardness of 46 HRC to 50 HRC in accordance with ISO 6508-1.

The edge of the impact surface shall have a radius less than 1 mm. When this radius is exceeded, it shall be re-sharpened before use.

6.3 Handle specification

The axe head (see 6.2.1) and the hammer head (see 6.2.2) shall be fixed to a handle as shown in Figure 3. The top edge of the tool shall be flush with the end of the handle. The handle shall be made of high-density polyethylene with a density of (940 ± 3) kg/m^3 and a modulus of (400 ± 20) N/mm^2.

Dimensions in millimetres

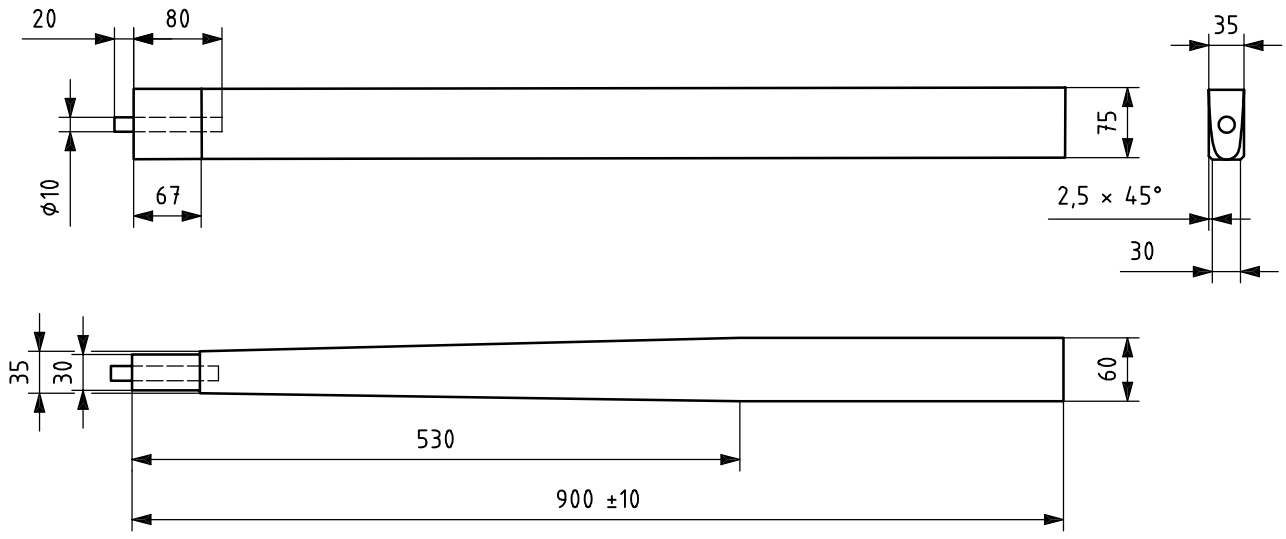


Figure 3 — Handle for the tools

6.4 Test piece support apparatus

The test piece support apparatus shall

— be inherently rigid;

— have an unyielding connection to a solid base and/or a sturdy wall;

— ensure plane and parallel clamping of the test piece in a vertical position;

— be designed in such a way that the test piece touches only the clamping frame during the test;

— ensure clamping of the test piece on all four edges with an edge cover of 30 $\pm$ 5mm;

— have the clamping frame covered on the contact area of the test piece with rubber strips 30 mm wide and 4 mm thick of hardness 40 IHRD to 60 IHRD according to method N of ISO 48:1994;

— ensure that the edges of the test piece are clamped with a uniform pressure of 140 $\pm$ 20 kN/m^2.

6.5 Mechanism for simulating a hand-held axe

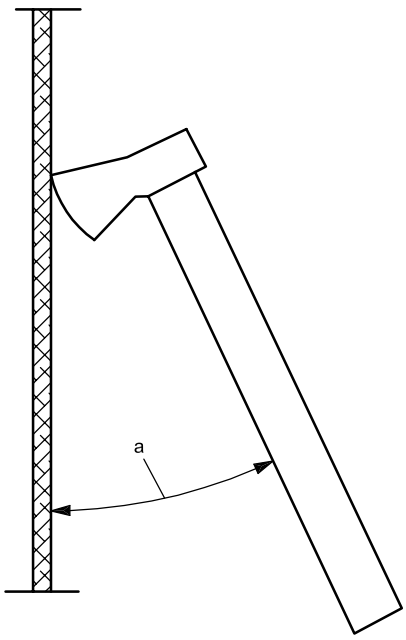
The mechanism for simulating the action of a hand-held axe shall

— be rigid in itself;

— have an unyielding connection to a solid base and/or a sturdy wall;

— ensure that the angle, a_i, of impact between the surface of the test piece and the handle is (25 $\pm$ 2)$^\circ$ at the point of impact, see Figure 4;

— be designed in such a way that the mass of the components moving during each strike achieves the impact energy, E_i, in accordance with Table 2.



[a] $a_i = 25^\circ \pm 2^\circ$.

Figure 4 — Angle of impact

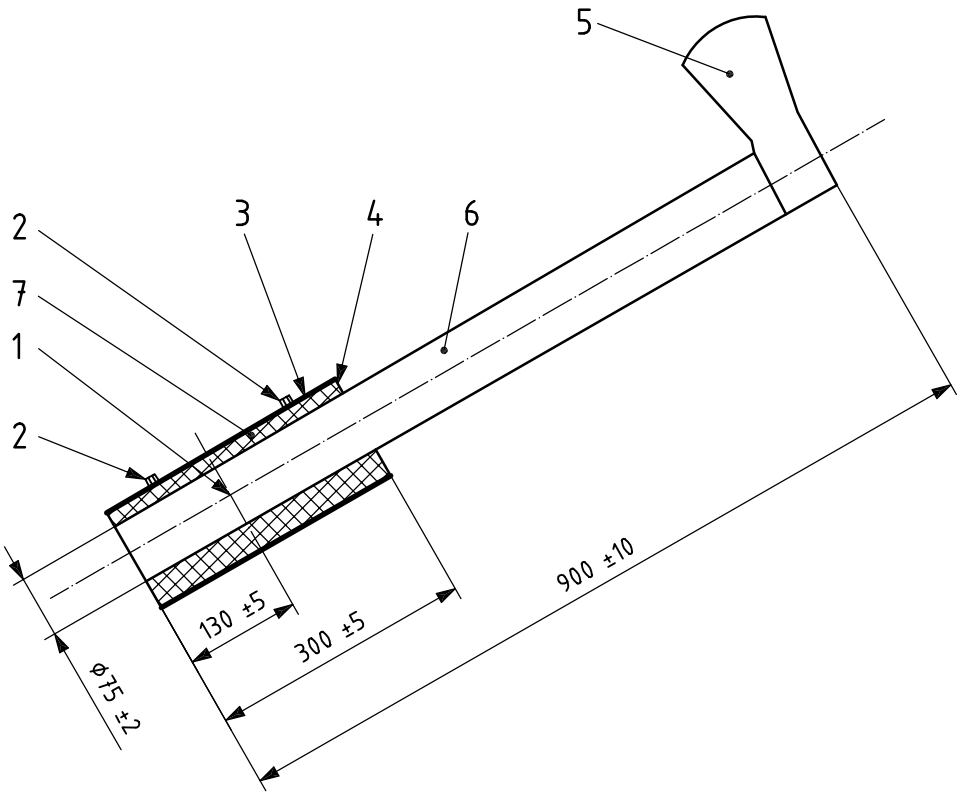
The lower end of the handle shall be fixed over a length of (300 ± 5) mm in a rigid sleeve that is rigidly attached to the axis of rotation (see Figure 5). The method of fixing shall include the following.

— On the side of the handle opposite the direction of the strike, the handle shall be separated from the sleeve by a rubber strip (60 ± 2) mm wide by (300 ± 5) mm long by (25 ± 1) mm thick, of hardness 17 IRHD to 23 IRHD according to method L of ISO 48:1994.

— On the side of the handle towards the direction of strike, the handle shall be clamped by a steel plate (60 ± 2) mm wide by (300 ± 5) mm long by (6,0 ± 0,1) mm thick, with a surface pressure of (100 ± 20) kN/m^2.

— The distance from the axis of rotation to the end of the handle shall be (770 ± 10) mm.

Dimensions in millimetres



Key

1 axis of rotation
2 screws
3 sleeve
4 steel plate
5 tool
6 handle
7 rubber

Figure 5 — Attachment of the handle

6.6 Impact velocity measuring equipment

The apparatus shall incorporate equipment for measuring the impact velocity, v_i, to an accuracy in accordance with the tolerances in Table 2. The velocity shall be measured corresponding to a distance of (770 $\pm$ 10) mm from the axis of rotation.

Table 2 — Testing conditions

Category of resistance	Simulation of a hand-held axe				
	Hammer strikes		Cutting strikes		Total number of strikes
	Impact velocity v_i m/s	Impact energy E_i Nm	Impact velocity v_i m/s	Impact energy E_i Nm	
P1B	12,5 $\pm$ 0,3	350 $\pm$ 15	11,0 $\pm$ 0,3	350 $\pm$ 15	30 to 50
P2B	12,5 $\pm$ 0,3	350 $\pm$ 15	11,0 $\pm$ 0,3	350 $\pm$ 15	51 to 70
P3B	12,5 $\pm$ 0,3	350 $\pm$ 15	11,0 $\pm$ 0,3	350 $\pm$ 15	over 70

7 Required characteristics

The security-glazing product shall be submitted to testing for a particular category of resistance.

The security-glazing product shall be classified in a particular category of resistance if all three test pieces require at least the minimum number of strikes for that category of resistance in order to create an opening when tested by the method described in Clause 8.

8 Test method

8.1 Test-room temperature

The test-room temperature shall be (18 $\pm$ 5) °C.

8.2 Installation of test piece

The test piece shall be placed vertically, the attack face facing the hammer and axe, into the clamping frame of the test piece support apparatus and fixed in accordance with the requirements of 6.4.

The surface of the test piece shall be marked to indicate the location of the clamping frame relative to the test piece. This is to check for slippage of the test piece during the test.

8.3 Test procedure

8.3.1 Impact velocity

The impact velocity, v_i, of each strike shall be measured.

8.3.2 Objective of test

The objective of the test is to produce a square opening with a side length of (400 $\pm$ 10) mm in such a manner that the centre of the square opening is coincident with the centre of the sample and in such a way that the minimum number of strikes of hammer and axe, combined, are used.

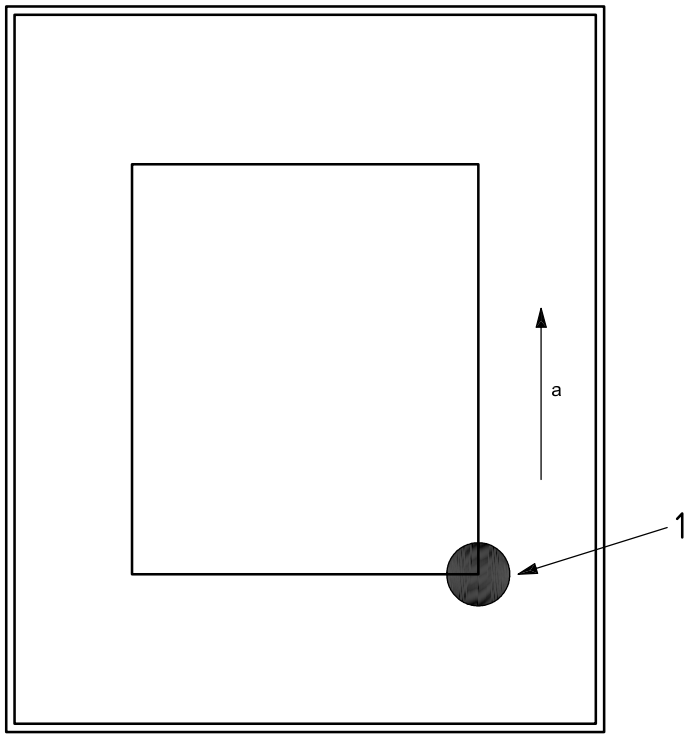
8.3.3 Detailed procedure

8.3.3.1 Determination of hammer impacts

The glass plies shall be destroyed around the side of the square opening by hammer impacts before the axe is used.

8.3.3.2 Position of hammer impacts

The test shall be started with the longest edge of the test piece in the vertical position. At the first point of impact (position 1 in Figure 6), the hammer strikes as many times as are necessary to break all the glass plies before moving on to the next position (see Figure 6). If some of the glass plies remain unbroken after 10 impacts, the position of the impact shall be moved 50 mm and the procedure continued.



Key

1 first impact position

[a] Progress of impact positions.

Figure 6 — First point of hammer impact and progress of impact positions

The distance between two consecutive hammer impact positions shall be such that the fractured areas border upon each other. The distance shall be not less than 50 mm and not more than 130 mm. At each position, the hammer strikes as many times as necessary to break all the glass plies. If some of the glass plies remain unbroken after 10 impacts, the position of the impact shall be moved 50 mm and the procedure continued.

After the glass plies have been smashed along one side of the square opening, the test piece and clamping frame are rotated clockwise through 90° and the hammer impacts continued along the second side, followed similarly by the third and fourth sides.

The minimum number of hammer impacts shall always be 12, i.e. if at each position all the glass plies are broken by the first impact and one can progress by 130 mm between two impact positions. The positions of the minimum number of hammer impacts shall be in accordance with Figure 7.

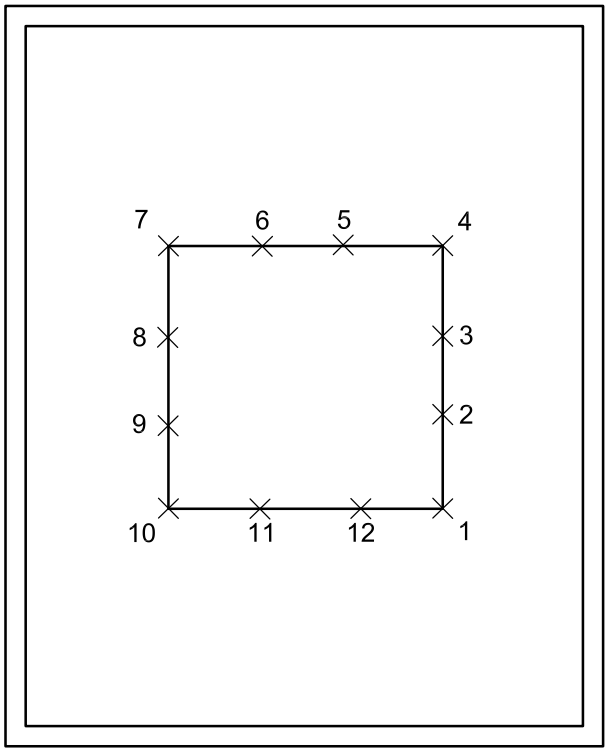


Figure 7 — Hammer impact positions for minimum number of impacts

8.3.3.3 Position of axe impacts

After the hammer strikes have been applied, the first axe strike shall hit in the same position as the first hammer strike.

The test piece shall be placed, with the longest edge of the test piece in the vertical position, such that the lower extremity of the cutting edge of the axe head is level with the lower side of the square opening, which has to be cut.

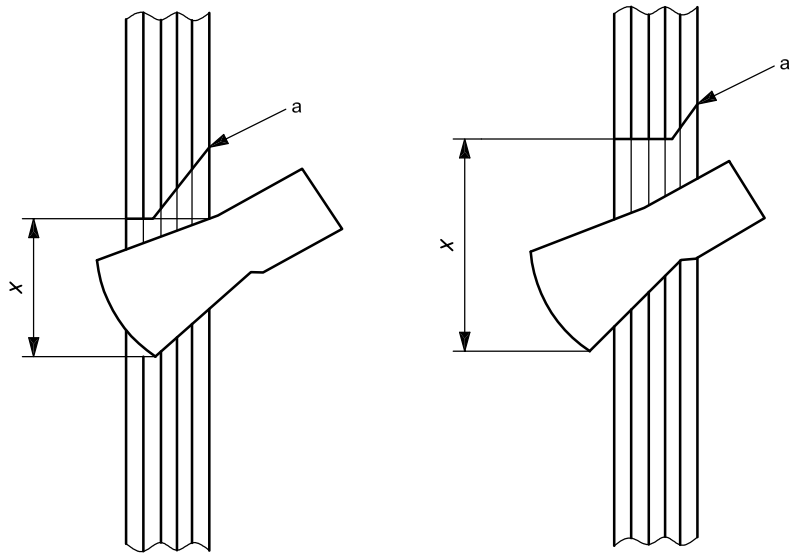
As many strikes, n_1, as are required to penetrate the test piece shall be applied to the first impact position.

When the test piece has been penetrated, the length, x, of the slit on the rear side of the test piece (see Figure 8) shall be estimated and the test piece shall be moved by a distance that is equal to the length of the slit to obtain the position of the next impact.

As many strikes as are required to penetrate the test piece shall be applied to the next impact position.

If, at any time, the number of strikes, n_2, required to penetrate the test piece is greater than the number, n_1, required at the first impact position, then the distance by which the test piece is moved shall be reduced by 10 mm, i.e. to (x − 10) mm, to obtain the position of subsequent impacts.

After one side of the square opening has been cut, the test piece and clamping frame shall be rotated clockwise through 90° and the axe impacts continued along the second side, followed similarly by the third and fourth sides.



[a] Top of slit.

Figure 8 — Penetration of the test piece

8.3.4 Optimisation of test procedure

The advancement values (positions of axe and hammer strikes) shall be noted for each of the test pieces and subsequent test pieces shall be tested in the most efficient way to minimise the number of strikes (axe and hammer) required.

8.4 Evaluation of the test results

A test piece has failed when the part of the test piece forming the square opening is completely detached from the rest of the test piece or, although still loosely attached, falls down under its own weight and thus creates the opening.

The number of strikes required to fail the test piece shall be counted. Both hammer strikes and axe strikes shall be counted. If a test piece has survived the number of strikes required to obtain the category of resistance for which it was submitted, the test could be stopped before failure, provided this does not affect optimisation (see 8.3.4)

During each test, the test piece is examined for signs of slippage from the clamping frame. The test is invalid if any edge of the test piece has moved more than 5 mm in the clamping frame. If this is the case, then the test shall be repeated with a new test piece. If it is found to be necessary to increase the clamping pressure to prevent slippage, this shall be stated in the test report.

The clamping pressure should not exceed 200 kN/m^2. High clamping pressures can make a product unsuitable for use in insulating units.

9 Classification and designation

The security glazing product shall be classified in that category of resistance corresponding to the least number of strikes required to fail any one of the three test pieces in the sample. Table 3 gives the code designations for the categories of resistance.

Table 3 — Classification table for the resistance of security glazing products

Category of resistance	Total number of strikes	Code designation for category of resistance
P1B	30 to 50	ISO … P1B
P2B	51 to 70	ISO … P2B
P3B	over 70	ISO … P3B

10 Test report

The following items shall be included in the test report:

— name of the testing laboratory;

— test number;

— date of test;

— reference to this standard;

— name of the company or authority submitting the sample for test;

— name (trade name or descriptive name) of the security glazing product;

— description of the composition of the security glazing product;

— the category of resistance that the sample was tested against in accordance with Table 1;

— the code designation of the category of resistance, if obtained, according to Table 3;

— test piece conditioning temperature;

— test room temperature;

— clamping pressure, if higher than (140 ± 20) kN/m^2.

11 Marking

Products that satisfy the requirements of this part of ISO 16936 shall be accompanied by a delivery note, which includes the code designation as given in Table 2 and the attack face of the product. The same code designation can be marked on the product itself, or, for reasons of security, the code designation on the product can be omitted.

Bibliography

[1] EN 356, *Glass in building — Security glazing — Testing and classification of resistance against manual attack*

ICS 81.040.20

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