BS EN 356:2000

Glass in building — Security glazing — Testing and classification of resistance against manual attack

The European Standard EN 356:1999 has the status of a British Standard

ICS 13.310; 81.040.20

National foreword

This British Standard is the official English language version of EN 356:1999.

The UK participation in its preparation was entrusted by Technical Committee B/520, Glass and glazing in building, to Subcommittee B/520/3, Security glazing, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This British Standard supersedes BS 5544:1978 immediately for the testing and classification of glass and glass/plastics composites. BS 5544 will however remain available for the testing and classification of plastics glazing sheet materials until a corresponding British Standard is published for these products.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 19 and a back cover.

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Glass in building - Security glazing - Testing and classification of resistance against manual attack

Verre dans la construction - Vitrage de sécurité - Mise à essai et classification de la résistance à l'attaque manuelle

Glas im Bauwesen - Sicherheitssonderverglasung - Prüfverfahren und Klasseneinteilung des Widerstandes gegen manuellen Angriff

This European Standard was approved by CEN on 20 February 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 356:1999 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 129, Glass in building, the Secretariat of which is held by IBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2000, and conflicting national standards shall be withdrawn at the latest by May 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard assesses security glazing products that are more familiarly known as “anti-bandit” and “anti-vandal” glazing products. Because there is no single test that will cover the wide range of resistances to attack, two separate test methods are used to give a continuous range of categories of resistance. It is not intended that either test method be associated with the terms “anti-bandit” or “anti-vandal”, particularly since these terms can be only loosely defined and there is considerable overlap in their definition.

The test methods specified in this standard do not reproduce the conditions of real human attack, but are intended to give a classification of comparative resistance.

1 Scope

This European Standard specifies requirements and test methods for security glazing designed to resist actions of force by delaying access of objects and/or persons to a protected space for a short period of time. This standard classifies security glazing products into categories of resistance to actions of force.

In this European Standard, the categories of resistance have not been assigned to special applications. Selection of categories should be made by the user for every individual case, after consulting an expert if necessary.

NOTE 1: Security glazing products should be installed in a frame which can give appropriate resistance to attack and which also provides a suitable support for the security glazing product.

NOTE 2: Cut-outs and holes in security glazing products should be avoided where possible, as these can affect the resistance of the product.

This European Standard deals with mechanical resistance to attack only. Other properties can also be important, for which separate standards will be prepared.

2 Normative references

This European Standard incorporates by dated or undated refererence, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

ISO 48:1994 Rubber, vulcanised or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD).

ISO 6508 Metallic materials - Hardness test - Rockwell test (scales A-B-C-D-E-F-G-H-K).

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1 **security glazing product** a 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.

3.2 **security glazing composition** a specific construction of a security glazing product

NOTE: A product is deemed to be of the same 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.

3.3 **protected space** the space protected against access by the completed installation

3.4 **action of force** a 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

3.5 **test piece** a specified piece of security glazing product submitted to a specified test procedure

3.6 **sample** a 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 European Standard

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

4 Symbols

α_i angle of impact, measured between the surface of the test piece and the handle, see Figure 5

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 type testing shall consist of three test pieces for each category for which testing is required.

NOTE: 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 ± 5) mm long × (900 ± 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 the test temperature, for at least 12 hours immediately prior to the test.

6 Apparatus

6.1 Hard body drop test

6.1.1 Impactor

The impactor (hard body) shall be a steel sphere with a diameter of (100 ± 0,2) mm and a mass of (4,11 ± 0,06) kg. The sphere shall be manufactured from polished steel with a hardness of 60 HRC to 65 HRC on the Rockwell C scale according to ISO 6508.

6.1.2 Impactor holding equipment

The equipment for holding the impactor shall enable adjustment of the drop height to the required tolerance (see Table 1). The equipment for holding the impactor and the mechanism for releasing the impactor shall not induce any momentum or rotation in the impactor, so that the impactor is accelerated only by gravitational forces and falls vertically.

Table 1: Drop heights

Category of resistance	Drop height mm
P1A	1 500 ± 50
P2A	3 000 ± 50
P3A	6 000 ± 50
P4A	9 000 ± 50
P5A	9 000 ± 50

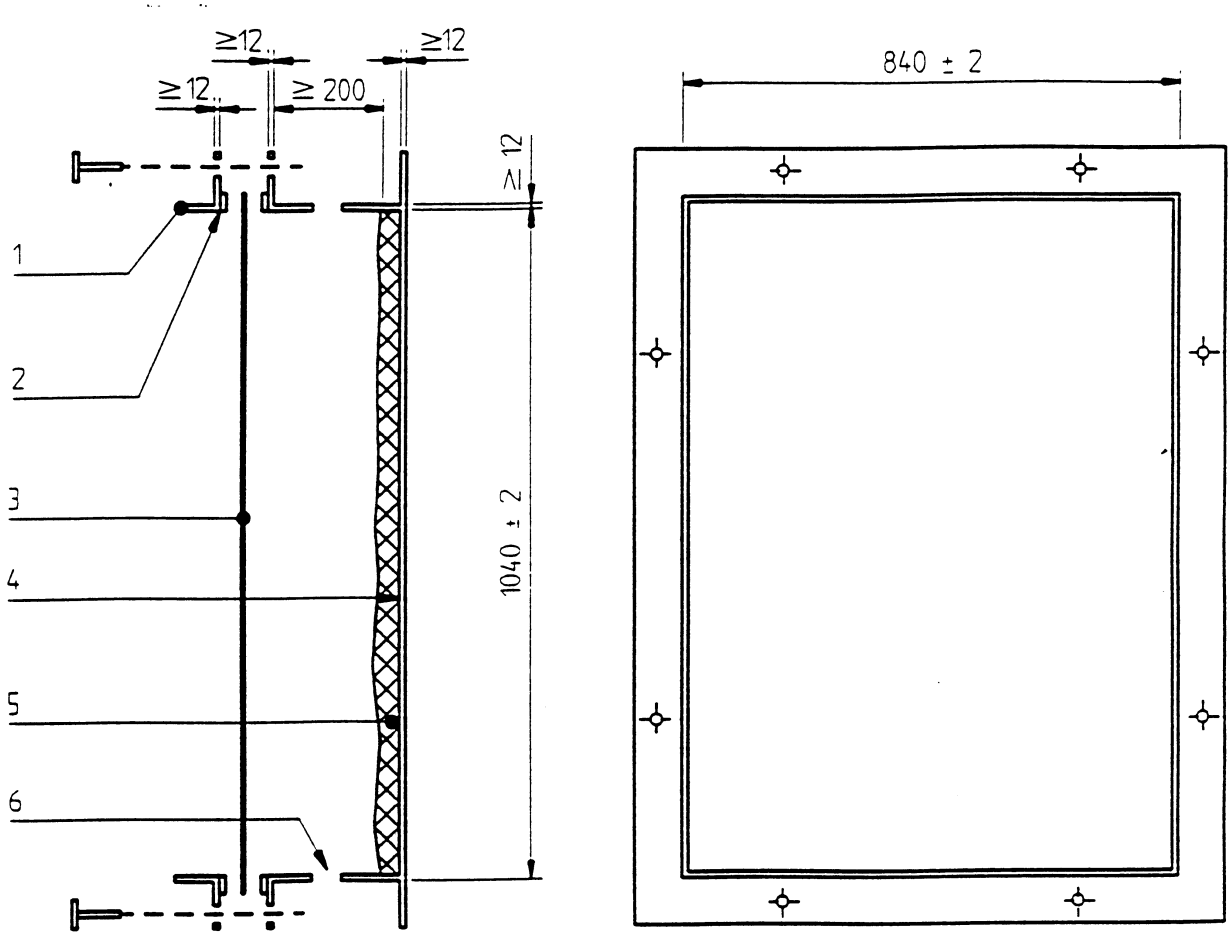
6.1.3 Test piece support apparatus

The test piece support apparatus (see Figure 1) shall consist of a steel frame to clamp the edge of the test piece and a receiving box to collect fragments and the impactor.

The support apparatus shall:

- be inherently rigid;
- have an unyielding connection to a solid base;
- ensure plane and parallel clamping of the test piece in a horizontal 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 ± 5) mm;
- 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 ± 20) kN/m^2;
- ensure that the impactor is not damaged and does not rebound when hitting the bottom of the receiving box;
- ensure that air cannot be trapped in the support apparatus in such a way that it may cushion the effects of the impact.

Dimensions in millimetres



1 Steel clamping frame
2 Rubber strip
3 Test piece
4 Steel receiving box
5 Energy absorber
6 Vent holes

Figure 1: Example of a test piece support apparatus

6.2 Axe test

6.2.1 General

Figure 2 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 6.2.2 to 6.2.4.

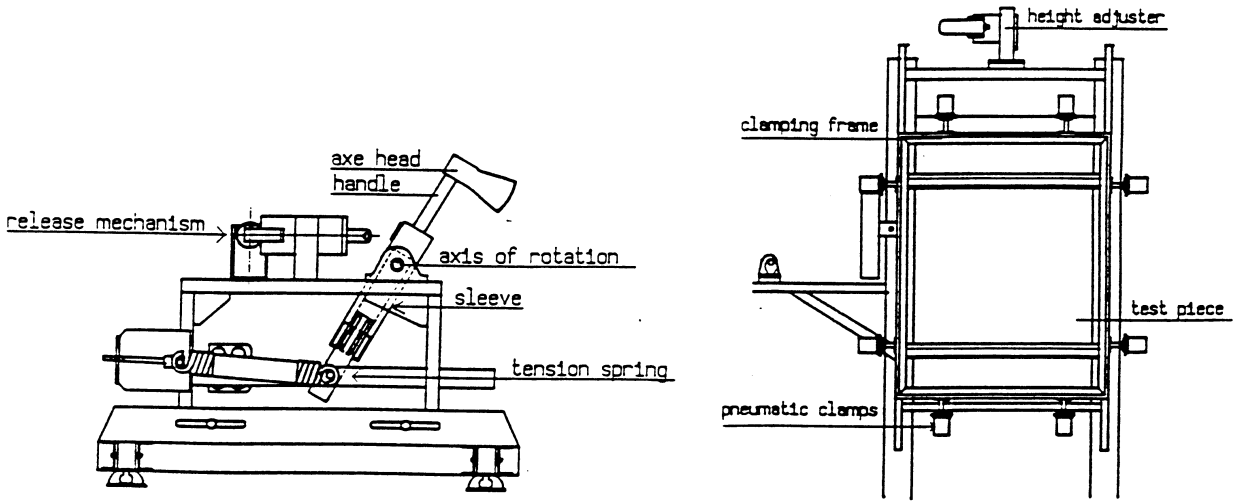


Figure 2: General view of axe test apparatus

6.2.2 Tool specifications

6.2.2.1 Axe head

The axe head shall have the form and dimensions as shown in Figure 3.

Dimensions in millimetres

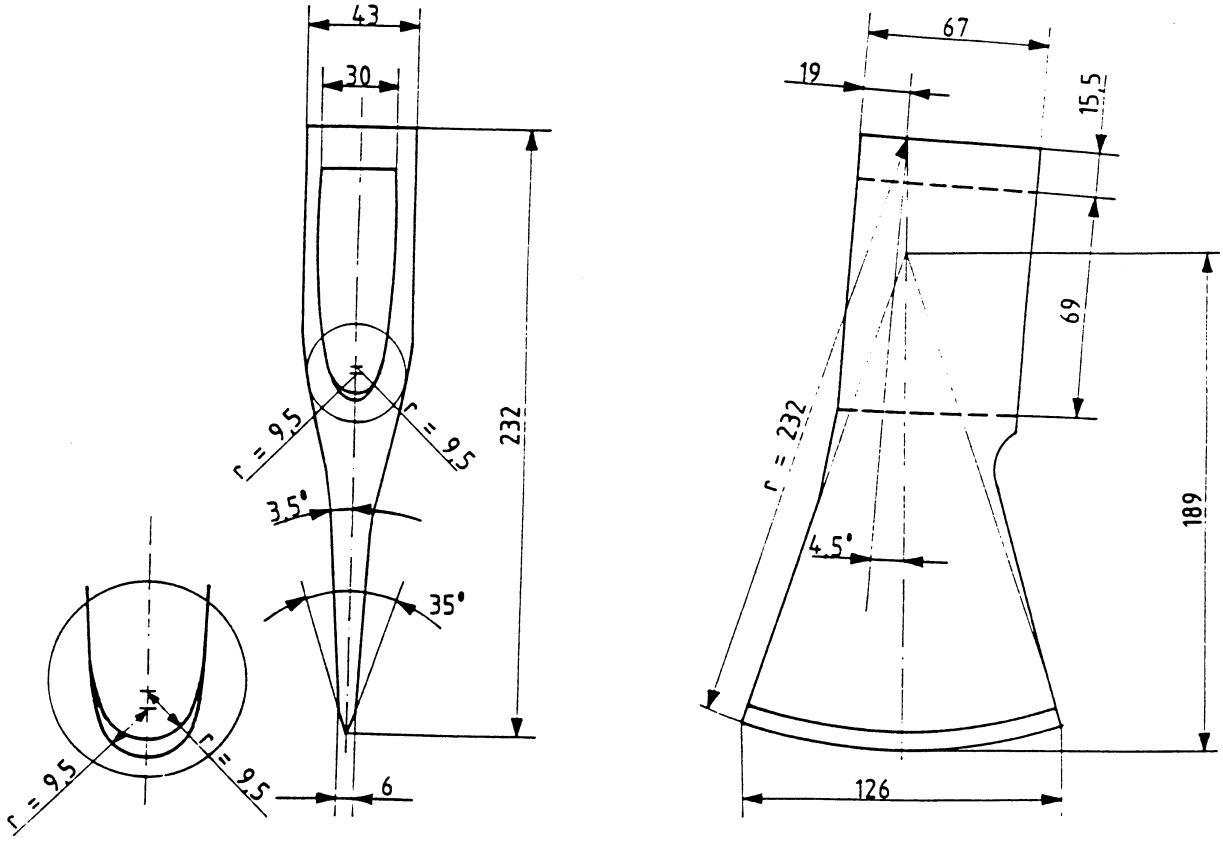


Figure 3: Axe head

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 2.

Table 2: Chemical composition of axe head

Percentages by mass

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 ± 1)°;
- a sligthtly convex flank;
- a blade radius, r_1, of 232^{0}_{-10} mm;
- a hardness of 51 HRC to 56 HRC according to ISO 6508.

After every 10 impacts, the blade shall be resharpened and checked for hardness.

An axe should not be reused 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.

6.2.2.2 Hammer head

The hammer head is designed to simulate the blunt edge of an axe head and is used fitted 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 ± 0,1) kg. The head shall have a hardness of 46 HRC to 50 HRC according to ISO 6508.

The edge of impact shall have a radius less than 1 mm. When the radius is higher it shall be resharpened before use.

6.2.3 Handle specification

The axe head (see 6.2.2.1) and the hammer head (see 6.2.2.2) shall be fixed to a handle as shown in Figure 4. 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 (935 ± 3) kg/m^3 and a modulus of (400 ± 20) N/mm^2.

Dimensions in millimetres

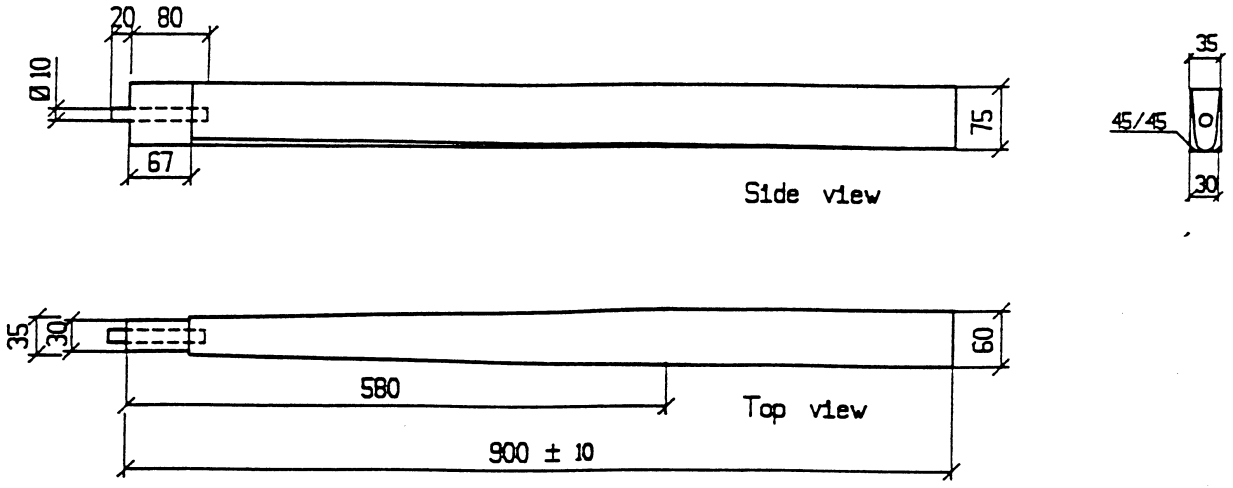


Figure 4: Handle for the tools

6.2.4 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 ± 5) mm;
- 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 ± 20) kN/m^2.

6.2.5 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 impact velocity, v_i (see 6.2.6), is in accordance with Table 3;
- ensure that the angle of impact, α_i, between the surface of the test piece and the handle is (25 ± 2)° at the point of impact, see Figure 5;
- 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 3.

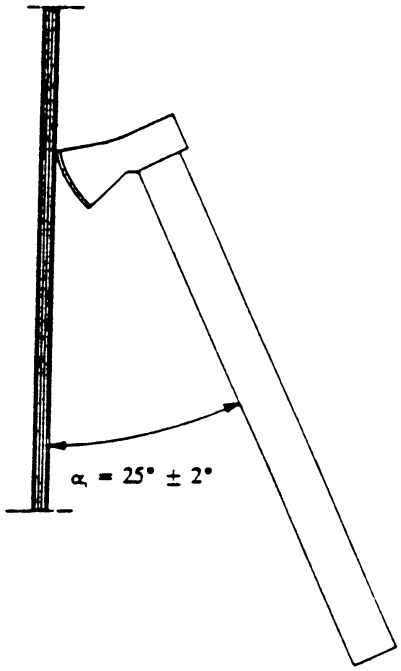


Figure 5: Angle of impact

The lower end of the handle shall be fixed over a length of (300 ± 5) mm in a rigid sleeve which is rigidly attached to the axis of rotation (see Figure 6). 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

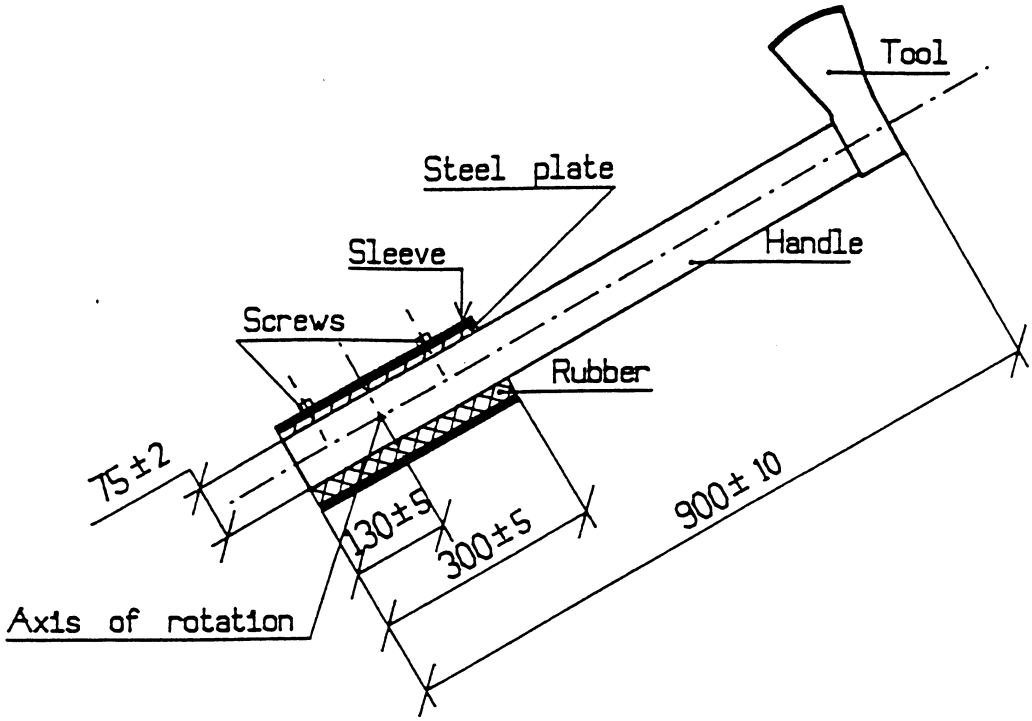


Figure 6: Attachment of the handle

Table 3: 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	
P6B	12,5 ± 0,3	350 ± 15	11,0 ± 0,3	300 ± 15	30 to 50
P7B	12,5 ± 0,3	350 ± 15	11,0 ± 0,3	300 ± 15	51 to 70
P8B	12,5 ± 0,3	350 ± 15	11,0 ± 0,3	300 ± 15	over 70

6.2.6 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 3. The velocity shall be measured corresponding to a distance of (770 ± 10) mm from the axis of rotation.

7 Required characteristics

7.1 Resistance to hard body impact

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

The security glazing product shall be classified in that particular category of resistance if all three test pieces prevent penetration by the impacting body when tested by the method described in clause 8.

7.2 Resistance to axe attack

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 9.

8 Test method for drop test

8.1 The test temperature shall be (23 ± 2) °C.

8.2 Installation of test piece

The test piece shall be placed horizontally into the clamping frame of the test piece support apparatus and fixed in accordance with the requirements of 6.1.3.

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

The drop height (measured from the bottom of the impactor to the surface of the test piece) shall be adjusted according to Table 1 for the category of resistance to be tested.

For categories P1A, P2A, P3A and P4A, the impactor shall be dropped on to each test piece three times from the same height, in such a way that the impact positions form the pattern of an equilateral triangle with a side length of (130 ± 20) mm around the geometric centre of the test piece, with one side of the triangle parallel to a short side of the specimen. The impact position opposite to this side of the triangle shall be hit first.

For category P5A, the above procedure shall be repeated a total of three times on each test piece, giving nine impacts, three on each point of the triangle.

Loose fragments shall be removed from the test piece after each impact.

8.4 Evaluation of the test results

After each impact, the test piece shall be checked for penetration by the impactor. A test piece shall be regarded as being penetrated if the impactor has completely passed through the test piece before five seconds has elapsed since the time of impact.

After each impact, the test piece shall also be 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 and the type test attestation.

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

9 Test method for axe test

9.1 Test temperature

The test temperature shall be (23 ± 2) °C.

9.2 Installation of test piece

The test piece shall be placed vertically into the clamping frame of the test piece support apparatus and fixed in accordance with the requirements of 6.2.4.

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.

9.3 Test procedure

9.3.1 Impact velocity

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

9.3.2 Objective of test

The objective of the test is to produce a square opening with a side length of (400 ± 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.

9.3.3 Detailed procedure

9.3.3.1 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.

The minimum number of hammer impacts shall be 12.

9.3.3.2 Position of hammer impacts

The test shall be started with the longest edge of the test piece in the vertical direction. The positions of the minimum number of hammer impacts shall be according to Figure 7.

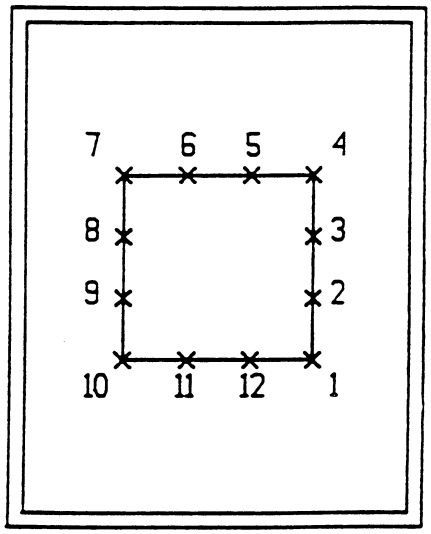


Figure 7: Hammer impact positions for minimum number of impacts

At the first point of impact (position 1 in Figure 7), the hammer strikes as many times as are necessary to break all the glass plies before moving on to the next position. 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.

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 are 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.

9.3.3.3 Position of axe impacts

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

The test piece shall be placed, with the longest edge of the test piece in the vertical direction, 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, in mm, 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, x_1 that is equal to the length of the slit to obtain the position of the next impact, i.e. $x_1 = x$.

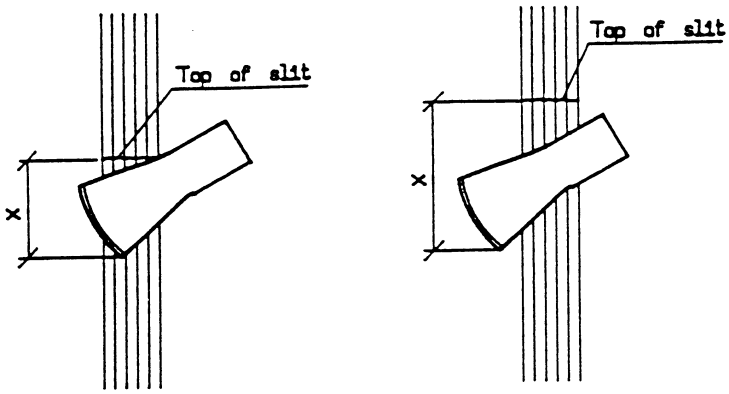


Figure 8: Penetration of the test piece

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, x_2, by which the test piece is moved shall be reduced by 10 mm, i.e. to $x_2 = (x\text{-}10)$ 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.

9.3.4 Optimization 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 minimize the number of strikes (axe and hammer) required.

9.4 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 can be stopped before failure provided this does not affect optimization (see 9.3.4).

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 and type test attestation.

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

10 Classification and designation

10.1 Drop test

The security glazing product shall be classified in that category of resistance corresponding to the applied drop height and number of impacts, provided all three test pieces have resisted penetration by the impactor.

Table 4 gives the code designations for the categories of resistance.

10.2 Axe test

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 4 gives the code designations for the categories of resistance.

Table 4: Classification table for the resistance of security glazing products

Category of resistance	Drop height mm	Total number of strikes	Code designation for category of resistance
P1A	1 500	3 in a triangle	EN 356 P1A
P2A	3 000	3 in a triangle	EN 356 P2A
P3A	6 000	3 in a triangle	EN 356 P3A
P4A	9 000	3 in a triangle	EN 356 P4A
P5A	9 000	3 × 3 in a triangle	EN 356 P5A
P6B	-	30 to 50	EN 356 P6B
P7B	-	51 to 70	EN 356 P7B
P8B	-	over 70	EN 356 P8B

11 Test report and type test attestation

11.1 Test report

The following items shall be included in the test report:

- the name of the testing laboratory;
- test number;
- date of test;
- reference to this standard;
- name (trade name or descriptive name) of the security glazing product;
- name of the company or authority submitting the sample for test;
- description of the composition of the security glazing product;
- the category of resistance that the sample was tested against according to Table 1 or Table 3;
- the code designation of the category of resistance, if obtained, according to Table 4;
- clamping pressure, if higher than (140 ± 20) kN/m^2.

11.2 Type test attestation

The following items shall be included in the type test attestation:

- the name of the testing laboratory;
- test number and attestation number;
- date of test;
- reference to this standard;
- name (trade name or descriptive name) of the security glazing product;
- name of the company or authority submitting the sample for test;
- the code designation of the category of resistance according to Table 4;
- clamping pressure, if higher than (140 ± 20) kN/m^2.

12 Marking

Products which satisfy the requirements of this European Standard shall be accompanied by a delivery note which includes the code designation as given in Table 4. 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.

The code designation can be accompanied by other indications concerning conformity with other European Standards.

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