
**Glass in building — Bullet-resistant
security glazing — Test and classification**

*Verre dans la construction — Vitrages de sécurité résistant aux
balles — Essai et classification*

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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 16935 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*.

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Glass in building — Bullet-resistant security glazing — Test and classification

1 Scope

This International Standard sets forth test procedures to evaluate resistance of security glazing materials and products against ballistic impact with classification by weapon and ammunition.

This International Standard is applicable to attack by handguns, ammunition fired from machine pistols or submachine guns, rifles and shotguns, on products used for glazing in buildings, for both interior and exterior use.

NOTE 1 For exterior use under extreme conditions, it is necessary to consider the influence of the outside temperature as described in 6.1 and Annex B.

This International Standard assumes the glazing will be adequately fixed, but does not apply to the glazing system or the surrounding materials and structure.

NOTE 2 Considerations for installation are given in Annex C. Considerations for the bullet-resistance of other elements of the protective structure are given in Annex D.

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

3 Terms and definitions

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

3.1

glass

any glass product including annealed glass (e.g. float glass), patterned glass, wired glass, heat strengthened glass, toughened glass, laminated glass, which may include panes of any or all of the above types of glass, and plastic glazing sheet material

3.2

glazing

glass or plastic glazing sheet material

3.3

glazing system

framing or other means of holding the glass in position in use, including all fixings, beads and glazing materials such as gaskets, glazing compounds, etc.

3.4

plastic glazing sheet material

flat plastic materials in sheet form suitable for glazing into windows, etc.

NOTE The commonly available plastics for this purpose are acrylic, polycarbonate and PVC.

3.5

rigidity

product of the modulus of elasticity of a material and the moment of inertia (*I*) value of the material section

4 Sample

The sample shall consist of three test specimens, with at least one extra test specimen as a reserve.

The test specimens shall conform to the specification of the manufacturer and shall be representative of normal production quality.

The test specimens shall be (500 ± 5) mm square and shall be clearly identified by type and construction and with an indication of the attack face.

NOTE Sizes in use smaller than the size of the test specimens might not perform to the same level as the test specimens.

5 Apparatus

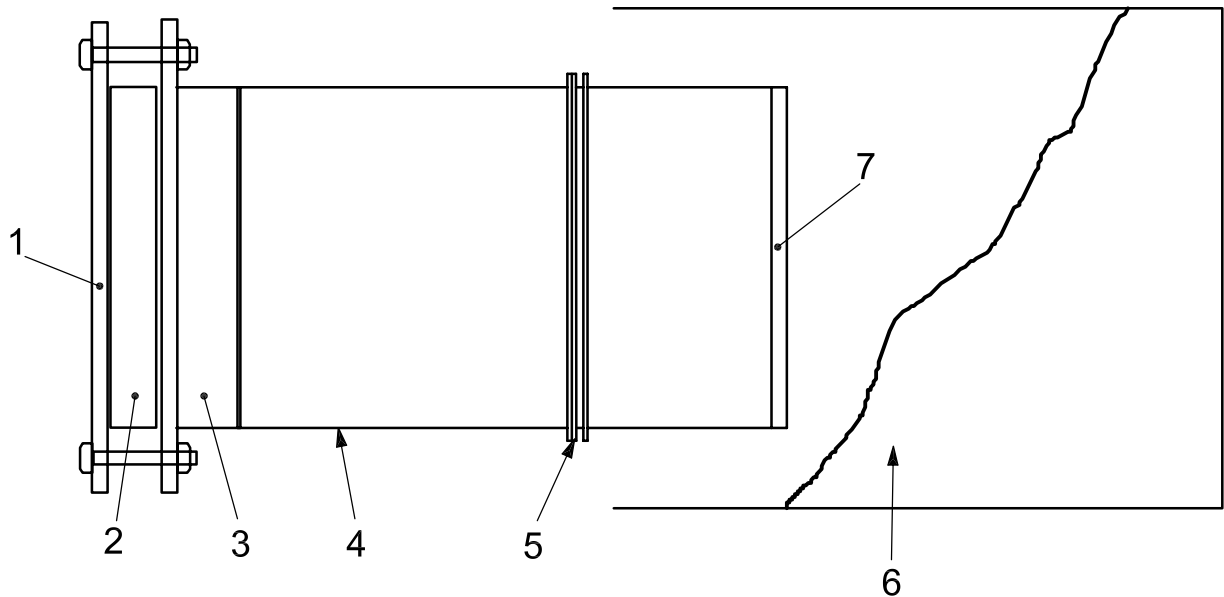
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5.1 General

The apparatus shall consist of the following: [ISO 16935:2007
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- rigid frame;
- splinter-collecting box;
- witness foil;
- bullet and debris stop;
- velocity measuring equipment;
- ballistic testing equipment.

The apparatus is shown schematically in Figure 1.

**Key**

- 1 clamping plate
- 2 glazing
- 3 rigid frame
- 4 splinter-collecting box
- 5 witness foil
- 6 bullet and debris stop
- 7 steel plate, 6 mm

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Figure 1 — Schematic diagram of the apparatus

5.2 Rigid frame

The preconditioned test specimen shall be mounted in a frame, along the full length of all four edges, with a sight size (440 ± 2) mm \times (440 ± 2) mm.

The frame shall be provided with a clamping plate to hold the glazing in position and means for producing uniform clamping of the glazing.

The test specimen shall be mounted in the frame in a manner which meets the following requirements.

- The test specimen shall have an edge cover of not less than 25 mm on all edges.
- The test specimen shall be separated from the frame and the clamping plate by continuous rubber strips, $(4 \pm 0,5)$ mm thick, (30 ± 5) mm wide and of hardness (50 ± 10) IRHD, in accordance with ISO 48.
- At the bottom of the rebate, the glazing shall be seated on rubber strips, of thickness 4 mm, of hardness (50 ± 10) IRHD in accordance with ISO 48 and of width equal to the full thickness of the test specimen.
- All four edges of the test specimen shall be uniformly clamped with a clamping pressure sufficiently large that the edges remain in position during the test.

The clamping pressure has relatively little effect on the test results for glass but can have considerable influence on the test results for plastic glazing sheet materials. For these materials, the manner of support and retention should be reported.

The test specimen in the frame shall be placed normal to the direction of attack with an accuracy of ± 1 in any orientation.

NOTE A high degree of accuracy can be obtained by ensuring the reflection of the weapon is in the centre of the test specimen when viewed through the sights with the weapon in position.

5.3 Splinter-collecting box

A splinter-collecting box shall be mounted between the rigid frame and the witness foil. The splinter-collecting box should have an opening of at least 440 mm \times 440 mm that matches the sight size of the glazing and should fully enclose the gap between the frame and the witness foil. The splinter-collecting box should extend beyond the witness foil and be terminated with a 6 mm steel plate in order to contain target and low-residual-velocity bullet fragments that can pass through the witness foil for visual inspection. It is not intended to arrest all bullets which can pass through targets at high velocity.

5.4 Witness foil

The witness foil shall consist of a sheet of aluminium of thickness 0,02 mm and density 54 g/m², mounted parallel to the test specimen, with a clear surface of at least 440 mm \times 440 mm that matches the sight size of the glazing.

The witness foil shall be at a distance of (500 \pm 10) mm behind the test specimen.

The witness foil shall be mounted by its edges in a manner that stretches it tight and ensures it remains in position during the test, but with no tendency for the witness foil to tear at the edges.

5.5 Bullet and debris stop

For the safety of test personnel, observers and others, the target and its mounting shall be placed in front of a means of stopping the bullet should it miss the target or pass through it with substantial retained velocity.

5.6 Velocity measuring equipment

The velocity of the bullet (see Tables 1 and 2) shall be measured or determined with an electronic measuring system no more than 3 m in front of the test specimen. The measuring mechanism shall be accurate to 1,0 m/s.

For each test specimen, the mean velocity of the bullets shall be within ± 10 m/s of the required velocity.

For classification SG2, both of the individual bullet velocities shall be within ± 10 m/s of the required velocity.

For each classification requiring three shots, at least two of the individual bullet velocities shall be within ± 10 m/s of the required velocity and the other bullet velocity shall be within ± 15 m/s of the required velocity.

5.7 Ballistic testing equipment

The ballistic testing equipment shall conform to the weapons and ammunition requirements for bullet composition, mass and velocity given in Tables 1 and 2. In the case of the open class, the weapon, bullet composition, mass and velocity shall be in accordance with the requirements and tolerances given before the start of the test.

It is not necessary that the equipment be the specific weapon listed, but may be specially designed equipment to give the required striking velocity. Attainment of the specified striking distance and accuracy can require special barrels and special sights; and attainment of the specified velocity can require the use of specially selected or manufactured ammunition. Classification in accordance with this International Standard presupposes the use of purpose-designed equipment in a fixed firing range usually using remotely fired weapons to obtain consistency of results in a safe manner.

6 Test method

6.1 General

The test method is given for testing for glazing for interior use.

Alternatively, if the glazing is intended for use under extreme conditions, the test specimens shall be tested at one or both of the following extreme temperatures as required: $(-20 \pm 3) ^\circ\text{C}$ or $(+40 \pm 3) ^\circ\text{C}$, and the test shall be conducted according to Annex B.

If there is a requirement for natural weathering, all the test specimens shall be subjected to the weathering regime prior to the test.

6.2 Conditioning

The test specimens shall be stored for at least 12 h at a temperature of $(18 \pm 5) ^\circ\text{C}$ immediately prior to the test; see also Annex B.

6.3 Procedure

6.3.1 Ballistic testing equipment

The weapon and ammunition shall be selected from Tables 1 or 2 according to the level of bullet-resistance required.

If it is required that the glazing be tested to particular specifications of weapon or ammunition not in accordance with Tables 1 and 2, it shall be tested according to the "open class" (see Table 3). For the purpose of comparing products, it is recommended that the test requirements given in Annex A be respected. In the case of the open class, the type of weapon, ammunition, mass and velocity shall be in accordance with the requirements and tolerances given before the start of the test.

6.3.2 Mounting the test specimen

The test specimen shall be mounted in the frame and positioned at the appropriate distance from the muzzle of the weapon according to Tables 1 or 2. In the case of the open class, the distance shall be in accordance with the requirements and tolerances given before the start of the test. Unless there is good reason or a special requirement, the distance shall be not less than the relevant range stated in Tables A.1 and A.2 of Annex A.

6.3.3 Test conditions

The test temperature shall preferably be $(18 \pm 5) ^\circ\text{C}$. In the case of unheated or external ranges, the glass shall be mounted and tested within 10 min of removal from the conditioning area. For testing at extreme temperatures, see also Annex B.

6.3.4 Strike positions

Mark the centre of the test specimen. The position(s) of the strike points shall be marked as follows:

- Classes HG1, HG2, HG3, (three shots): at the vertices of an equilateral triangle of side length (110 ± 2) mm around the centre of the test specimen;
- Classes R1, R2, SG3 (three shots): at the vertices of an equilateral triangle of side length (120 ± 2) mm around the centre of the test specimen;