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Glass in building — Destructive-windstorm-resistant security glazing — Test and classification

bsi.

National foreword

This British Standard is the UK implementation of ISO 16932:2016.

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Glass in building — Destructive-windstorm-resistant security glazing — Test and classification

Verre dans la construction — Vitrages de protection résistant aux tempêtes destructrices — 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.

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 second edition cancels and replaces the first edition (ISO 16932:2007), which has been technically revised.

INTERNATIONAL STANDARD ISO 16932:2016(E)

Glass in building — Destructive-windstorm-resistant security glazing — Test and classification

1 Scope

This International Standard determines resistance of security glazing products to natural threats characterized by simulated destructive-windstorm events. Classification is intended as a basis for judging the ability of glazing to remain essentially without openings during a tropical cyclone with wind speed of 50 m/s or greater. Impact by missile(s) and subsequent cyclic static-pressure differentials simulate conditions representative of windborne debris and pressures in a destructive windstorm. Glazing is tested in a standard frame. Classification is based on the potential hazard to human life using the appropriate wind speed, pressure and level of protection.

The test method determines the performance of security glazing for use in fenestration assemblies under conditions representative of events that occur in severe, destructive-windstorm environments using simulated missile impact(s) followed by the application of cyclic static-pressure differentials.

A missile-propulsion device, an air pressure system and a test chamber are used to model some conditions that can be representative of windborne debris and pressures in a windstorm environment.

The performance determined by this test method relates to the ability of glazing in the building envelope to remain without openings during a windstorm.

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)*

3 Terms and definitions

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

3.1
security glazing
glass-based fenestration glazing products, usually transparent or translucent, intended to protect property or people from natural threats

3.2
destructive windstorm
severe weather event with high winds and turbulent gusts, such as tropical cyclones having a *basic wind speed* (3.3) equal to or greater than 50 m/s, capable of generating *windborne debris* (3.11)

3.3
basic wind speed
V
wind speed as determined by the authority having jurisdiction

Note 1 to entry: The basic wind speed is intended to represent the gust wind speed design basis for a tropical cyclone, such as used to describe a 50-year recurrence period or annual 0,02 probability of being exceeded.

3.4
fenestration assembly
glazing system intended to be installed in a building

EXAMPLE Exterior windows and glazed doors.

3.5
air-pressure differential
P
specified maximum differential in static air pressure across the specimen, creating an inward or outward load

Note 1 to entry: The air-pressure differential is expressed in Pascal or its multiples.

3.6
missile
object that is propelled toward a *test specimen* (3.8)

3.7
positive (or negative) cyclic test load
specified differential in static air pressure, creating an inward or outward load, to which the specimen is subjected in a series of cycles

3.8
test specimen
glazing materials and glazing unit assembled in a standard frame

Note 1 to entry: See Annex B.

3.9
test-loading programme
entire sequence of air-pressure cycles applied to the *test specimen* (3.8)

3.10
lumber missile
dressed piece of surface-dried, soft-wood, structural timber that impacts the glazing surface of the specimen

3.11
windborne debris
objects carried by the wind in windstorms

3.12
design pressure
uniform, static air-pressure difference, inward or outward, for which the *test specimen* (3.8) is designed under service load conditions, using local conventional structural engineering specifications and concepts

Note 1 to entry: This pressure is determined by either analytical or wind-tunnel procedures.

4 Principle and significance

4.1 General

This test method consists of mounting the test specimen and testing to an appropriate class, by impacting the test specimen with (a) missile(s) and then applying cyclic static-pressure differentials across the test specimen in accordance with a specified test-loading programme. The condition of the test specimen is observed and measured, and the results reported.

4.2 Purpose

The purpose of this International Standard is to determine the resistance of various glazing materials and glazing systems to threats characteristic of destructive windstorms. Qualification under this International Standard provides a basis for judgment of the ability of elements of the building envelope to remain without openings during a tropical cyclone. This minimizes the damaging effects of a destructive windstorm on the building interior and reduces the magnitude of internal pressurization.

4.3 Options

The user of this International Standard either

a) tests the glazing material to a specified and required "level of protection" for classification according to 9.3, or

b) tests the glazing material to other conditions without classification as requested by the authority having jurisdiction, in which case, the required information, as described in Annex A, shall be provided for the test procedure.

5 Apparatus

5.1 General

Any equipment capable of performing the test procedure within the allowable tolerances may be used.

5.2 Equipment

5.2.1 Mounting frame

This fixture supports the outer specimen test frame(s) described in Annex B in a vertical position during testing. The maximum mounting-frame deflection of the longest member (either during impact or at the maximum specified static air-pressure differential) shall not exceed $L/360$, where L denotes the longest unsupported length of a member of the mounting frame. Frame-deflection measurements shall be made normal to the plane of the specimen at the point of maximum deflection. The mounting frame shall be either integral with the test chamber or capable of being installed into the test chamber prior to or following missile impact(s). The mounting frame shall be anchored so it does not move when the specimen is impacted. The specifications for the inner and the outer specimen-support frame are shown in Annex B.

5.2.2 Air-pressure cycling test chamber

This consists of an enclosure or box with an opening against which the test specimen is installed. It shall be capable of withstanding the specified cyclic static-pressure differential. The chamber shall be deep enough to avoid contact with the test specimen during pressure cycling. Pressure taps shall be provided to facilitate measurement of the cyclic static-pressure differential. They shall be located such that the measurements are unaffected by the air supplied to or evacuated from the test chamber or by any other air movements.

5.2.3 Air-pressure system

A controllable blower, a compressed-air supply/vacuum system or other suitable system capable of providing the required maximum air-pressure differential (inward and outward acting) across the test specimen. Specified pressure differentials across the test specimen shall be imposed and controlled through any system that subjects the test specimen to the prescribed test-loading programme. Examples of suitable control systems include manually operated valves, electrically operated valves or computer-controlled servo-operated valves.

5.2.4 Air-pressure-measuring apparatus

Pressure differentials across the test specimen shall be measured by an air-pressure-measuring apparatus with an accuracy of ±2 % of its maximum rated capacity, or ± 100 Pa, whichever is less, and with a response time of less than 50 ms.

EXAMPLE Acceptable apparatus are mechanical pressure gages and electronic pressure transducers.

5.2.5 Missile-propulsion device(s)

This is a device capable of propelling a missile at a specified speed and orientation towards a specified impact location; see Annex C. The missile shall not be accelerating upon impact due to the force of gravity along a line normal to the specimen.

5.2.6 Speed-measuring system

This is a system capable of measuring missile speeds within the tolerances defined in 7.3.2.

5.2.7 Missiles

5.2.7.1 General

Missiles shall be one or more of the following as appropriate to classification; see 9.2. Any other representative missiles shall have mass, size, shape and impact speed determined by engineering analysis considering the design basic wind speed.

5.2.7.2 Small-ball missile

A solid steel ball weighing 2 g ± 5 %, with an 8 mm nominal diameter, and an impact speed between 0,40 and 0,80 of the basic wind speed; see Table 4.

5.2.7.3 Lumber missile

The lumber missiles, typically, have a relative density of 0,48; a hardness of 2 600 N, as measured by a modified Janka hardness test;[9] and cross-section dimensions of 38 mm × 89 mm, with a linear density between 1,61 kg/m and 1,79 kg/m. The timber, generally called “2 × 4s” in reference to its nominal dimensions of 2 in by 4 in, shall have a mass and an impact speed as shown in Table 1. The missile shall have no defects, such as knots, splits, checks, shakes or wane, within 30 cm of the impact end. The impact end shall be trimmed square. If required for propulsion, a circular sabot having a mass of no more than 0,2 kg may be applied to the trailing edge of a large missile. The mass of the large missile includes the mass of the sabot.

5.3 Calibration

5.3.1 Speed-measuring system

The speed-measuring system shall be calibrated to an accuracy of ±2 % of the elapsed time required to measure the speed of the specified missile. Calibration shall be performed at the manufacturer’s recommended frequency, but in any event, not more than six months prior to the test date. The speed-measuring system shall be calibrated by at least one of the following methods:

— photographically, using a stroboscope and a still camera;

— photographically, using a high-speed motion-picture or video camera with a frame rate exceeding 500 frames per second capable of producing a clear image and a device that allows single-frame viewing;

— using gravity to accelerate a free-falling object having negligible air drag through the timing system and comparing measured and theoretical elapsed times;

— using any independently calibrated speed-measuring system with an accuracy of ±1 %.

5.3.2 Pressure transducers

Electronic pressure transducers shall be calibrated at six-month intervals using a standardized calibrating system or a manometer readable to 10 Pa (1 mm of water).

5.3.3 Manometers

The calibration of manometers is normally not required, provided that the instruments are used at a temperature near their design temperature.

6 Test specimens

6.1 General

The test specimens shall consist of the glazing panel mounted in a test frame.

Entire fenestration assemblies may be tested in a similar way.

6.2 Glazing material

The glazing material tested shall be nominally (1 100 ± 5) mm × (900 ± 5) mm and shall be representative of the commercial production.

6.3 Number of samples

Three test specimens shall be submitted for the lumber-missile or small-ball-missile test.

6.4 Order of testing

Test specimens passing the acceptance criteria of the lumber-missile or small-ball-missile impact test shall be submitted for the air-pressure-cycle test.

7 Test procedure

7.1 General

Glazing materials shall be tested to a class appropriate to its use, as described in Clause 9. Basic wind speed and level of protection is specified by the authority having jurisdiction or as directed by the test client. If the intent is to classify the glazing, the following test information shall be provided:

a) basic wind speed;

b) level of protection;

c) maximum specified air-pressure differential (if different from Table 4).

If the glazing material is tested at other conditions required by the authority having jurisdiction, then the required information shall be provided, as described in Annex A.

7.2 Preparation

7.2.1 Installation

Support and secure the test specimen into the standard mounting frame in a vertical position. The test specimen shall not be removed from the mounting frame at any time during the test sequence.

7.2.2 Conditioning

Unless otherwise specified, condition the specimens separately for at least 4 h within a temperature range of 18 °C to 28 °C.

7.2.3 Missile impact

Take the following steps to prepare the specimen for missile impact.

— Secure the specimen and mounting frame, such that the missile (lumber missile or small-ball missile) impacts the exterior side of the specimen as installed.

— Locate the end of the propulsion device from which the missile exits at least 1,5 times the length of the missile from the specimen. This distance shall be no less than 1,80 m.

— Set up appropriate signal/warning devices to prevent test and/or other personnel from coming between the propulsion device and the test specimen during testing.

— Weigh each missile prior to starting the test.

— Load the missile into the propulsion device.

— Reset the speed-measuring system.

— Align the missile-propulsion device, such that the specified missile impacts the test specimen at the specified location.

7.3 Missile impact test

7.3.1 Projectile descriptions

Propel the small ball or proper lumber missile at the impact speed specified in Table 1. For classification, refer to Table 3.

Table 1 — Applicable missiles

Missile type	Missile	Impact speed m/s
A	(2 ± 0,1) g (small steel ball)	39,7
B	(1 ± 0,1) kg (small lumber)	15,3
C	(2,05 ± 0,1) kg (small lumber)	12,2
D	(4,1 ± 0,1) kg (medium lumber)	15,3
E	(4,1 ± 0,1) kg (medium lumber)	24,4
NOTE Missile type, mass and speed correlate with ASTM E1996-06. ASTM E1996 is a copy written document available at www.astm.org. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 USA. Data is used by permission.		

7.3.2 Impact-speed tolerance

Tolerances for the measured missile speed at any point after the missile acceleration caused by the propulsion device equals zero are as follows:

— ±2 % when the specified speed is ≤20 m/s;

— ±1 % when the specified speed >20 m/s.

7.3.3 Impact angle

Upon impact, the longitudinal axis of missiles having a longitudinal axis shall not deviate more than 5° from a line normal to the specimen at the specified impact point.

NOTE To ensure that the expected missile rotation prior to impact is less than 5° from a horizontal datum, measure the vertical height to the centre of the exit end of the propulsion device (if it is horizontal), h_B, and the vertical height to the centre of the missile impact point on the specimen, h_l, then:

$$5° \leq \tan^{-1}\left|\frac{h_B - h_l}{d}\right|$$

where d denotes the horizontal distance from the exit end of the propulsion device to the specimen.

7.3.4 Impact location

7.3.4.1 Lumber-missile test

Impact each glazing test specimen once, as shown in Figure 1 a).

a) Impact one specimen with the missile within a 65 mm radius circle at the centre of specimen.

b) Impact a different specimen with the missile within a 65 mm radius circle with the centre located 150 mm from supporting members at a corner.

c) Impact the remaining specimen with the missile within a 65 mm radius circle having its centre located 150 mm from supporting members at a diagonally opposite corner.

7.3.4.2 Small-ball-missile test

Impact each glazing test specimen three times with 10 steel balls each, as shown in Figure 1 b). Each specimen shall receive a total of 30 impacts from steel balls.

a) The corner-impact locations shall be entirely within a 250 mm radius circle having its centre located 275 mm from the corner edges.

b) The edge-impact locations shall be entirely within a 250 mm radius circle having its centre located at 275 mm from the edges and located at the centre line between two corners.

c) The centre-impact location shall be entirely within a 250 mm radius circle having its centre located at the horizontal and vertical centre line of the specimen.

7.3.5 Retesting

If necessary to retest, repeat steps 7.2.3 and 7.3.1 to 7.3.4 at all additional impact locations specified for test specimen.

7.4 Air-pressure-cycling test

7.4.1 General

Specimens passing the acceptance criteria for the lumber-missile or small-ball-missile impact test shall be subjected to the air-pressure-cycle test. If the mounting frame is not integral within the test chamber, attach the mounting frame to the test chamber, such that the exterior side of the test specimen faces outward from the chamber.

7.4.2 Leakage

If at any time during testing, the specified maximum pressure differential cannot be achieved in either direction due to excessive air leakage, tape may be used to cover cracks and joints through which leakage occurs. Tape shall not be used when there is a probability that it can restrict significantly differential movement between adjoining segments of the specimen. If excessive leakage exists and tape cannot be used, both sides of the test specimen may be covered with a single thickness of polyethylene or other plastic film no thicker than 0,050 mm. The technique of application is important in order that the full load is permitted to be transferred to the test specimen and that the film does not prevent movement or failure of the test specimen. Apply the film loosely with extra folds of material at each corner and at all offsets and recesses. When the load is applied, there shall be no effect caused by tightness of the plastic film.

7.4.3 Air-pressure differential

The maximum air-pressure differential, P, as defined in 3.5, is specified by the authority having jurisdiction, or it is equal to the design pressure assigned for worst exposure. Unless otherwise specified, use Table 4 for classification purposes.

NOTE Pressure differentials used in the air pressure cycling test can be determined as the design pressure differentials for the building and the other structure in accordance with codes and/or standards of each country and region. In this case, the pressure differentials may have positive and negative values, $P_{positive}$ and $P_{negative}$, respectively.

7.4.4 Cyclic test load

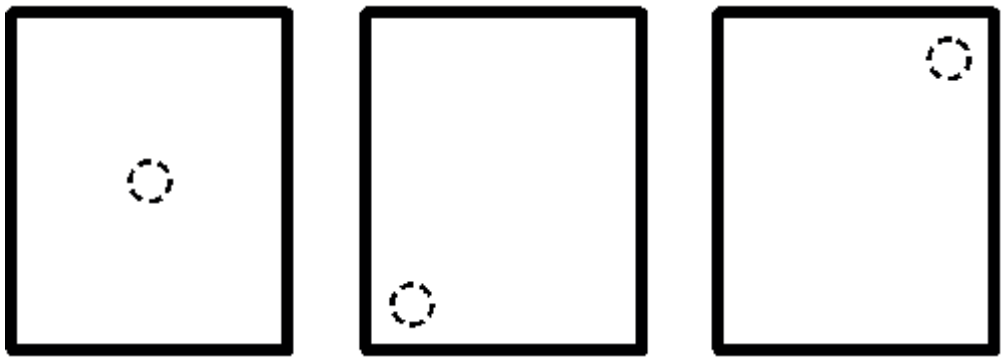
Unless otherwise specified, apply the static air-pressure-differential cyclic test load programme in accordance with Table 2 in which P denotes the maximum air-pressure differential. Unless otherwise specified, the duration of each air-pressure cycle shall not be less than 1 s and not more than 5 s. Dwell time between successive cycles shall be no more than 1 s.

— Interruptions of the cycle for equipment maintenance and repair shall be permitted.

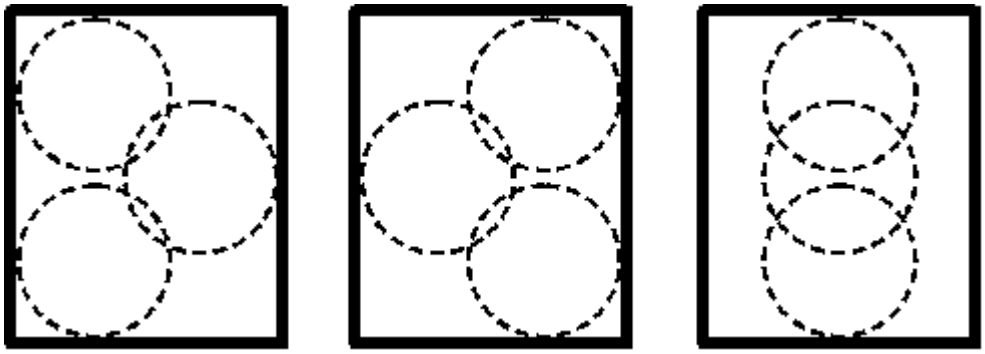
— The test specimen shall not contact any portion of the test chamber at any time during the application of the cyclic static-pressure-differential loading.

Table 2 — Cyclic static air-pressure differentials

Loading sequence	Loading direction	Air-pressure differential	Number of air-pressure cycles
1	Positive	0,2 P to 0,5 P	3 500
2	Positive	0,0 P to 0,6 P	300
3	Positive	0,5 P to 0,8 P	600
4	Positive	0,3 P to 1,0 P	100
5	Negative	0,3 P to 1,0 P	50
6	Negative	0,5 P to 0,8 P	1 050
7	Negative	0,0 P to 0,6 P	50
8	Negative	0,2 P to 0,5 P	3 350



a) Impact location for lumber-missile test (each type of glazing)



b) Impact locations for small-ball-missile test (each type of glazing)

Key

A specimen 1
B specimen 2
C specimen 3

Figure 1 — Impact locations

8 Test requirements

8.1 General

To satisfy the criteria of the test method of this International Standard, the glazing shall remain substantially intact (without openings). For wind zone 4 or level of protection, level 4, the glazing shall resist all missile impact penetration.

8.2 Openings

In a glazing tested, no openings shall form through which a 76 mm diameter solid sphere can pass. No tears longer than 125 mm shall be formed.

8.3 Edge releases

If the glazing pulls out or releases from the edge of the test specimen frame as a result of impact without tearing, terminate the test and the glazing shall not be classified. Repeat the test using a new sample.

9 Classification

9.1 Requirements

Class depends primarily on the wind zone and level of protection. When tested using the standard frame (see Annex B), glazing material satisfying Clause 8 shall be classified as providing acceptable protection for a windstorm in terms of the number of missile impacts, the mass/size of the missile, the missile velocity and the maximum pressure differential, *P*; see Table 4. These are expressed as

— wind zone class (wind zone 1 to wind zone 4) for basic wind speed,

— level of protection (level 1 to level 4), and

— design height of the assembly above ground level.

9.2 Applicable missile

The applicable missile from Table 1 shall be chosen using Table 3 unless otherwise specified.

9.3 Levels of protection

There shall be four levels of potential hazard to human life defined in this International Standard based on building type and use. These levels are level 1 to level 4, which are to be specified by the authority having jurisdiction or as directed by the test client.

NOTE The following are examples of buildings requiring levels of designated protection.

— Level 1 is advised for unprotected buildings and other structures which are expected to have low hazard to human life in a cyclones and other severe storms. Buildings in this level may include, but are not restricted to, agricultural houses, temporary facilities and storage facilities.

— Level 2 is advised for protection of buildings and other structures which are expected to have moderate hazard to human life in cyclones and other severe storms. Buildings in this level may include, but are not restricted to, houses, commercial and industrial buildings.

— Level 3 is advised for protection of buildings and other structures which are expected to have a substantial hazard to human life in cyclones and other severe storms. Buildings in this level may include, but are not limited to, major office buildings, schools, shopping centers, hotels and other buildings and structures where a significant number of people congregate in one area.

— Level 4 is advised for enhanced protection of essential facilities. Buildings in this level may include, but are not limited to, hospitals and other health care facilities, fire, rescue, ambulance, and police stations, and buildings and other structures having critical national defence functions or designated as storm shelters during a severe storm.

9.4 Basic wind-speed zones

There shall be four basic wind speed zones:

— wind zone 1; Basic wind speed equal to or greater than 50 m/s and less than 55 m/s (50 m/s ≤ V < 55 m/s);

— wind zone 2; Basic wind speed equal to or greater than 55 m/s and less than 60 m/s (55 m/s ≤ V < 60 m/s);

— wind zone 3; Basic wind speed equal to or greater than 60 m/s and less than 65 m/s (60 m/s ≤ V < 65 m/s)

— wind zone 4; Basic wind speed equal to or greater than 65 m/s (V ≥ 65 m/s).

Gust wind speeds greater than 70 m/s are extremely destructive and special precautions shall be applied that are beyond the scope of this International Standard.

NOTE The value of basic wind speed in this subclause is indicated as gust wind speed. In case other wind speeds are used, such as 10-minute wind speed, refer to Annex D.

Table 3 — Required missiles for testing for classification

Height of assembly (elevation) m	Level of protection							
	Level 1		Level 2		Level 3		Level 4	
	>10	≤10	>10	≤10	>10	≤10	>10	≤10
Wind zone 1	N	N	A	C	A	D	D	D
Wind zone 2	N	N	A	C	A	D	D	D
Wind zone 3	N	N	A	D	A	D	D	E
Wind zone 4	N	N	A	D	A	D	D	E
NOTE A, B, C, D, and E refer to applicable missile types, as defined in Table 1. N means that testing is not required.								

Table 4 — Required air pressure differentials, P, for testing for classification

Zone	Basic wind speed m/s	Air-pressure differential for glazing tests P Pa
Wind zone 1	50 m/s ≤ V < 55 m/s	2 490
Wind zone 2	55 m/s ≤ V < 60 m/s	2 970
Wind zone 3	60 m/s ≤ V < 65 m/s	3 450
Wind zone 4	V ≥ 65 m/s	3 640

10 Report

10.1 General

Report the following information:

a) date of test and report;

b) name(s) and address(es) of the testing agency;

c) manufacturer's model number;

d) description of the test specimen, glazing thickness and the number of specimens tested;

e) detailed drawings or photograph of the test specimen, if necessary. Any deviation from the drawings or any modifications made to the test specimen to obtain the reported values shall be noted on the drawings and in the report;

f) identification or description of any special specification or criteria when the tests are made to check conformity of the test specimen to that particular specification or pass/fail criteria;

g) results for each test specimen.

10.2 Impact test

Report the following information:

a) location of impact(s) on each test specimen;

b) exact description of the missile including dimensions and mass;

c) missile speed and orientation at impact;

d) conditioning temperature of the specimens.

NOTE 10.2, c) orientation refers to the impact orientation of the missile to the glass, i.e. perpendicular, head on, etc.

10.3 Air cyclic pressure test

Report the following information:

a) cyclic static-pressure loading differential (s) and sequence;

b) maximum air-pressure differential, *P*, and its relationship to the design pressure;

c) statement as to whether or not tape or film, or both, were used to seal against air leakage, and whether, in the judgment of the test engineer, the tape or film influenced the results of the test.

10.4 Results

Report the following information:

a) description of the condition of the test specimens after completion of each portion of testing, including details of damage and any other pertinent observations;

b) statement that the tests were conducted in accordance with this test method;

c) results (pass or fail) for each test specimen;

d) classification for the glazing product tested in accordance with Clause 9;

e) statement of whether, upon completion of testing, the test specimens pass or fail in accordance with any specified criteria;

f) name(s) of individual(s) conducting the test and the author of the report;

g) signatures of persons responsible for supervision of the tests and a list of all observers;

h) statement of any additional data or information considered to be useful to a better understanding of the test results, conclusions or recommendations, should be appended to the report.

Annex A
(normative)

Required information

If it is not the intent to classify the glazing in accordance with Clause 9 but to test it at other conditions, the following test information shall be provided by the test client:

a) number of test specimens;

b) conditioning temperature of specimens and minimum cure, if appropriate;

c) pass/fail criteria, if different from test requirement of Clause 8;

d) basic wind speed;

e) maximum air-pressure differential and its relationship to the design pressure;

f) missile, and relationship to the classification defined in Clause 9, such as the following:

   1) description of the missile, including dimensions, mass, and tolerances;

   2) missile speed at impact, or the equation relating missile speed to basic wind speed, and missile orientation at impact;

   3) number of impacts;

   4) location of impacts on the test specimens and tolerances;

g) test-loading programme, and relationship to classification in Clause 9, such as the following:

   1) positive and negative cyclic test loads;

   2) number of cycles of cyclic test load sequence to be applied;

   3) minimum and maximum duration for each cycle;

h) whether or not certification of the calibration is required.

Annex B
(normative)

Standard test frame

This test procedure shall be conducted on specimens of glazing materials that are used in windows, doors, curtain walls or other fenestration products.

The standard test frame shall be capable of supporting rectangular glazing as shown in Figure B.1 to Figure B.3. Glazing panels mounted in the standard test frame shall be tested using the procedures outlined in this test method.

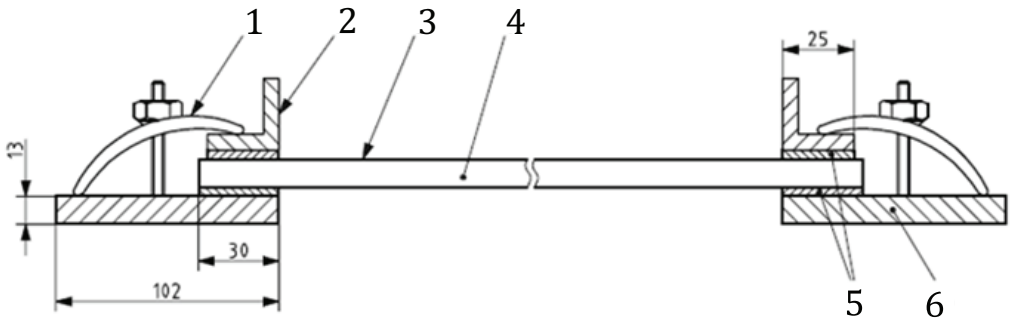
The typical frame dimensions of Figure B.1 to Figure B.3 shall provide (30 ± 5) mm minimum edge engagement on all edges.

The test specimen shall be separated from the frame and the clamping plate by continuous rubber strips, of thickness (4 ± 0,5) mm, of width (30 ± 5) mm and of hardness (50 ± 10) IRHD in accordance with ISO 48.

At the bottom of the frame, 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, but such that no stresses are induced in the test specimen that can affect the result.

Dimension in millimetres

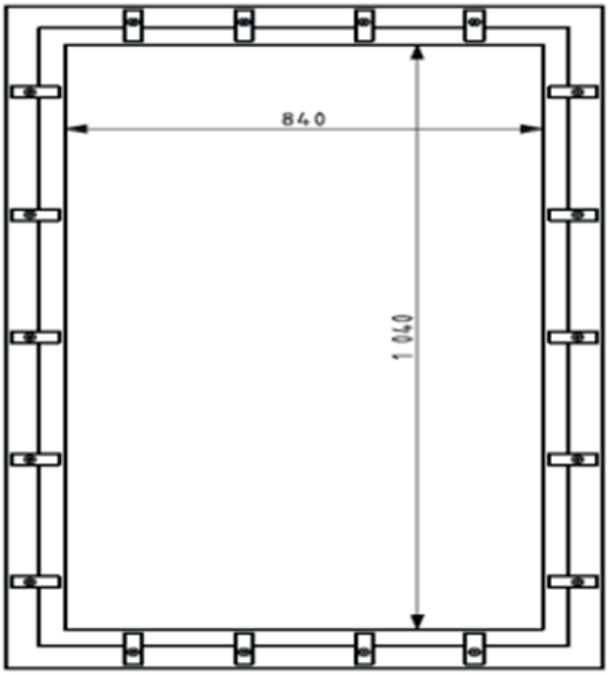


Key

1 clamp
2 inner frame
3 glazing specimen (900 mm × 1 100 mm)
4 test sample
5 rubber
6 outer frame

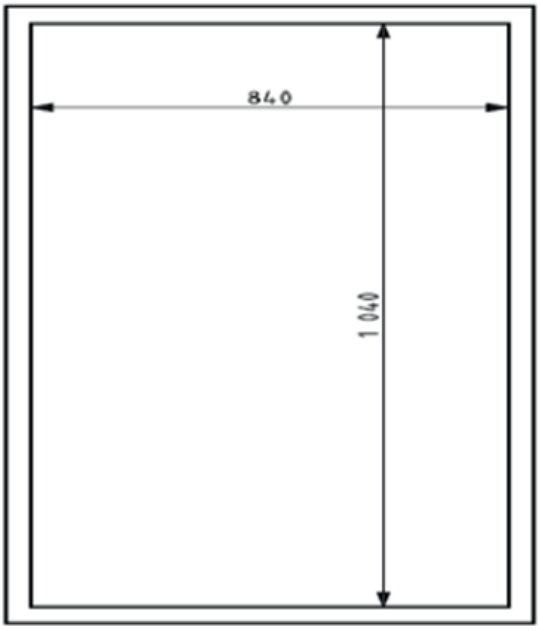
Figure B.1 — Schematic assembly of the normative frame

Dimension in millimetres



Fabricate using (102 × 13) mm flat stock steel

Figure B.2 — Outer frame



Fabricate using (25 × 25 × 3) mm angle iron

Figure B.3 — Inner frame

Annex C
(informative)

Recommended missile-propulsion devices

C.1 Large missile air cannon

C.1.1 General

The large missile air cannon shall use compressed air to propel the large missile. The cannon shall be capable of producing missile impact at the speeds as defined in this International Standard. The large missile cannon shall consist of four major components: a compressed-air supply, a pressure-release valve, a barrel and support frame and a speed-measuring system for determining missile speed.

C.1.2 Barrel

The barrel of the large missile cannon shall consist of a 100 mm nominal inside-diameter pipe and shall have a length at least as long as the missile. The total length of the barrel shall be the distance from the pressure valve to the vent holes before the timing system or to the mouth of barrel. The barrel of the large missile cannon shall be mounted on a support frame in a manner to facilitate aiming the missile so that it impacts the specimen at the desired location.

C.1.3 Missile

The large missile is as defined in this International Standard. The end of the missile that impacts the target is designated as the missile's impact end. The end of the missile opposite to the impact end is designated as the missile's trailing edge. A sabot shall be used at the trailing edge of the missile to facilitate launching.

C.1.4 Speed

The speed of the missile shall be measured at the trailing edge of the missile after it exits the barrel. The photoelectric sensors can be mounted on an extension such that the missile shall not be accelerating as its trailing edge passes between the photoelectric sensors.

C.2 Small-missile air cannon

A compressed-air cannon that is capable of propelling small missiles of the size and to the speed as defined in this International Standard shall be used. The cannon assembly shall be comprised of a compressed-air supply, a remote firing device, a barrel and a timing system. The small-missile cannon shall be mounted on a frame designed to permit movement of the cannon so that it can propel missiles to impact the test specimen at specified locations. The photoelectric sensors shall be positioned to measure missile speed within 150 cm of the impact point on the test specimen.

Annex D
(informative)

Basic wind speed

The basic wind speed in this International Standard indicates the 3-second gust wind speed. In the case other gust (3 s) wind speeds are used, such as the mean wind speed averaged over 10 min or 1 h, the following conversion formulae can be used referring to ISO 4354.[1]

$$V_{T=10min} = 0{,}69V_{T=3sec}$$

$$V_{T=1h} = 0{,}65V_{T=3sec}$$

where

$V_{T=3sec}$ is the 3-second wind speed;

$V_{T=10min}$ is the 10-minute mean wind speed;

$V_{T=1h}$ is the 1-hour mean wind speed.

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[1] ISO 4354, *Wind actions on structures*

[2] ASTM E1886 - 13a, *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*

[3] ASTM E1996-14a, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes*

[4] ANSI/ASCE 7, *Minimum Design Loads for Buildings and Other Structures*

[5] AS 1170.2, *SAA Loading code, Part 2: Wind Load*

[6] *SBCCI Test Standard for Determining Impact Resistance from Windborne Debris*, Southern Building Code Congress International, Inc., 900 Montclair Road, Birmingham, AL 35213-1206, USA, 1994

[7] Technical Record TR 440, *Guidelines for Testing and Evaluation of Products for Cyclone-prone Areas*, Department of Housing and Construction, Australian Government, Australia, February 1978

[8] Twisdale L.A., Vicery P.J., Steckley A.C. *Analysis of Hurricane Windborne Debris Impact Risk for Residential Structures*, Applied Research Associates Inc., Raleigh, North Carolina, USA, March 1996

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