भारतीय मानक

Indian Standard

IS 18518 : 2023

बुलेट प्रतिरोधी सुरक्षा काँच — गुणवत्ता और कार्यकारिता की अपेक्षाएँ

Bullet Resistant Security Glass — Quality and Performance Requirements

ICS 81.040.20, 43.040.65

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Glass, Glassware and Laboratoryware Sectional Committee, CHD 10

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Glass, Glassware and Laboratoryware Sectional Committee had been approved by the Chemical Division Council.

The Indian military and security forces face a number of small arms threats. It is important to set minimum performance requirements of bullet resistant security glass and also screen their supply so that only acceptable quality reaches the user which eventually leads to reduction in fatal casualties to the security forces using such bullet resistant security glasses.

Multiple test agencies in the country are involved in physical and ballistic testing of the bullet resistant security glasses. However, at present there is no common procedure in place to ensure inter-laboratory correlation of test results.

Many ammunitions defined in International Standards are not relevant in Indian context. The weapons and ammunitions handled (and faced) by the Indian forces have been categorized into specific threat levels.

In the formulation of this standard, considerable assistance has been derived from the following publications:

ISO 16935 : 2007	Glass in building — Bullet-resistant security glazing — Test and classification
BS EN 1063 : 2000	Glass in building — Security glazing — Testing and classification of resistance against bullet attack
IS 17051 : 2018	Textiles — Bullet resistant jackets — Performance requirements
ANSI Z26.1 : 1996	Safety glazing materials for glazing motor vehicles and motor vehicle equipment operating on land highways — Safety standard
ISO 12543-3 : 2021	Glass in building — Laminated glass and laminated safety glass — Part 3: Laminated glass
ISO 12543-4 : 2021	Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability

The composition of the Committee and the expert panel responsible for the formulation of this standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

BULLET RESISTANT SECURITY GLASS — QUALITY AND PERFORMANCE REQUIREMENTS

1 SCOPE

1.1 This standard prescribes the quality and performance requirements and the methods of sampling and test for bullet resistant security glass.

1.2 This standard is applicable to attack by handguns, ammunition fired from machine pistols or submachine guns, rifles and shotguns, on bullet resistant security glass used for glazing in bullet resistant structures.

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

NOTE — The tests described in the standard have inherent hazards, hence adequate safety norms for personnel and property should be employed strictly while conducting the tests.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards:

IS No.	*Title*
IS 1382 : 1981	Glossary of terms relating to glass and glassware (*first revision*)
IS 2553	Safety glass — Specification:
(Part 1) : 2018	Architectural, building and general uses (*fourth revision*)
(Part 2) : 2019	For road transport (*first revision*)
IS 4905 : 2015/ ISO 24153 : 2009	Random sampling and randomization procedures (*first revision*)
IS 17004 : 2018	Testing methods for processed glass

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions given in IS 1382 and IS 2553 (Part 1), in addition to the following shall apply:

3.1 Angle of Impact — The angle between the bullet's line of flight and the perpendicular to the strike face of the armour (Fig. 1).

3.2 Areal Density — Weight of an object per unit area generally expressed in kg/m^2.

3.3 Bullet Resistant Security Glass — An assembly of glass and/or plastic glazing sheet materials joined together with one or more interlayers to provide a defined resistance against the firing of specified weapons and ammunitions. The unit may be designed for protection with spall or anti-spall characteristics.

NOTE — The glass or plastic components of a unitary bullet resistant glass may also be separated by an air space.

3.4 Bullet Resistant Security Glazing — A security glazing that affords a defined resistance against the firing of specified weapons and ammunition.

3.5 Conditioning Protocols — Special test protocols designed to subject the product prior to ballistic testing, which consists of specified conditions of temperature, humidity, mechanical damage, etc.

3.6 Ballistic Limit — For a given projectile, the velocity at which the projectile is expected to perforate a panel 50 percent of the time. It is also denoted as V_{50}.

3.7 Fair Hit — The impact of a bullet on the bullet resistant glass that meets the requirements for shot spacing, angle of impact of bullet and velocity.

3.8 Full Metal Jacketed Bullet — A bullet made of lead completely covered, except for the base, with copper alloy (approximately 90 copper-10 zinc).

3.9 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.

3.10 Jacketed Soft Point Bullet — A bullet made of lead completely covered, except for the point, with copper alloy (approximately 90 copper-10 zinc).

3.11 Lead Bullet — A bullet made of lead alloyed with hardening agents.

3.12 Model — Design given by the manufacturer to uniquely identify a specific configuration for bullet resistant glass or glazing.

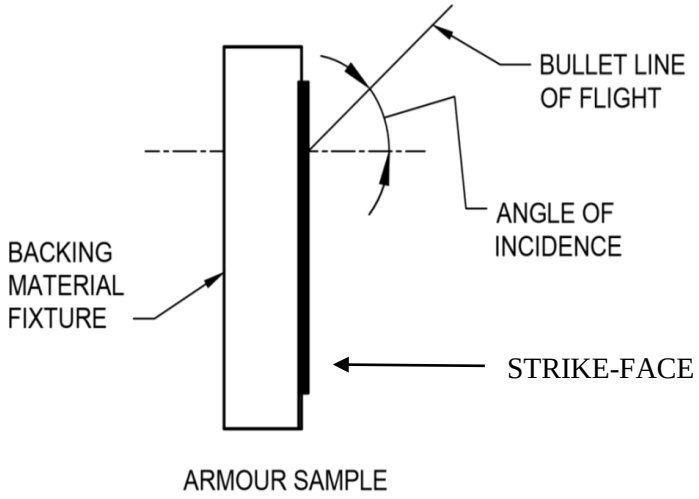


FIG. 1 ANGLE OF IMPACT (SIDE VIEW)

3.13 Operating Conditions — Environmental conditions which the bullet resistant glazing is likely to be subjected depending upon their location and usage.

3.14 Penetration — Entrance of a projectile into a target without completing its passage through it.

3.15 Perforation — Complete piercing of the target by the projectile.

3.16 Reference Velocity — The velocity (± tolerance) of the bullet specified by the user for ballistic testing of the bullet resistant glass to meet fair hit criteria.

3.17 Samples — A number of nominally identical glazing units offered for type-testing of a certain threat level.

3.18 Strike Face — The surface of the sample, designated by the user/manufacturer as the one facing the incoming ballistic threat.

3.19 Strike Velocity — The velocity of the bullet measured at a distance of 2.5 m in front of the strike face of the test piece.

3.20 Test Piece — One member of the sample prepared for testing.

3.21 Witness Sheet — A 0.5 mm thick sheet of aluminum alloy placed behind the glazing to serve as a means of determining perforation.

4 REQUIREMENTS

4.1 Quality Requirements

4.1.1 The test specimen shall satisfy the requirements for laminated safety glass as prescribed in Table 1.

4.1.2 *Thickness*

The thickness of the pane shall be calculated as the mean of measurements taken at the centres of the four sides with the help of a suitable vernier or micrometer to an accuracy of 0.01 mm. The mean shall be rounded to the nearest 0.1 mm. The individual measurements shall also be within the applicable limit deviation as given below.

The nominal thickness of laminated safety glass shall be the sum of the nominal thickness of constituent panes of glass and interlayer material. The limit deviation of the interlayer shall not be taken into account if the total interlayer thickness is < 2 mm.

If the total interlayer thickness is > 2 mm, a limit deviation of ± 0.2 mm shall apply. For plastics glazing sheet material, the limit of deviation on thickness shall be the same as applicable to a float glass of the same nominal thickness.

The limit deviations on thickness of laminated glass shall not exceed the sum of the limit deviations of the constituent glass panes as specified in Table 2 of IS 14900.

4.1.3 *Dimensions and Squareness*

When laminated glass sizes are quoted for rectangular panes, the first dimension shall be the width, *W*, and the second dimension shall be the length, *L* (or height *H* in the case of vertical glazing), as shown in Fig. 2.

The nominal dimensions, that is, width (*W*) and length (*L*) shall be as agreed to between the purchaser and the supplier. However, the finished pane shall not be larger than a prescribed rectangle of dimensions ($W+v$, $L+v$), or smaller than a prescribed rectangle of dimensions ($W-v$, $L-v$), where v is the maximum tolerance on nominal dimensions (*see* Table 2). The corresponding sides of the prescribed rectangles shall be parallel to each other and the rectangles shall have a common centre (*see* Fig. 3).

Table 1 Quality Requirements

(*Clause* 4.1.1)

Sl No.	Characteristic	Requirement	Test method
(1)	(2)	(3)	(4)
i)	Thickness	**4.1.2**	**5.1** of IS 17004
ii)	Dimensions and squareness	**4.1.3**	–
iii)	Edge displacement	**4.1.4**	–
iv)	Light stability test	**4.1.5**	**7.6** of IS 17004
v)	Bake test	**4.1.6**	**7.1.2** of IS 17004
vi)	Boil test	**4.1.7**	**7.1.1** of IS 17004
vii)	Defects in the central and outer area	**4.1.8.1** to **4.1.8.6**	**4.1.8.7**
viii)	Humidity test	**4.1.9**	**7.2** of IS 17004
ix)	Visual light transmittance, *Min* NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	**4.1.10.1**	**7.6.2.2** or **7.6.2.3** of IS 17004
x)	Resistance to abrasion NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	**4.1.10.2**	**6.6** of IS 2553 (Part 2)
xi)	Optical distortion test NOTE — Applicable only in case the glass is intended to be used as windscreens.	**4.1.10.3**	**6.12** of IS 2553 (Part 2)
xii)	Secondary image separation test NOTE — Applicable only in case the glass is intended to be used as windscreens.	**4.1.10.4**	**6.13** of IS 2553 (Part 2)
xiii)	Resistance to temperature change NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	**4.1.10.5**	**4.1.10.5**
xiv)	Resistance to fire test NOTE — Applicable only in case the glass is intended to be used for automotive vehicles and having an anti-spall (plastic) material.	**4.1.10.6**	**6.14** of IS 2553 (Part 2)
xv)	Resistance to chemical test NOTE — Applicable only in case the glass is intended to be used for automotive vehicles and having an anti-spall (plastic) material.	**4.1.10.7**	**6.15** of IS 2553 (Part 2)

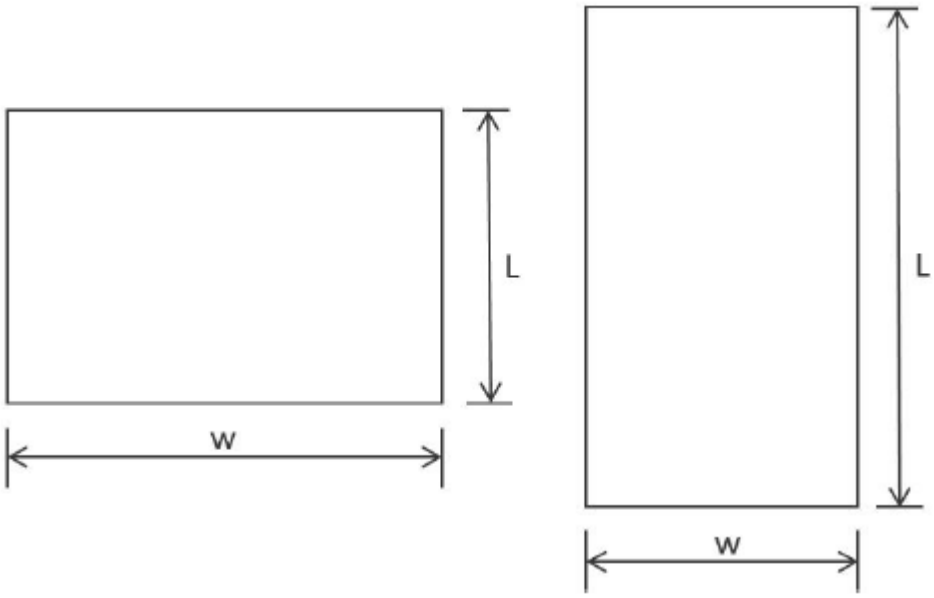


FIG. 2 EXAMPLES OF WIDTH AND LENGTH WITH RESPECT TO PANE SHAPE

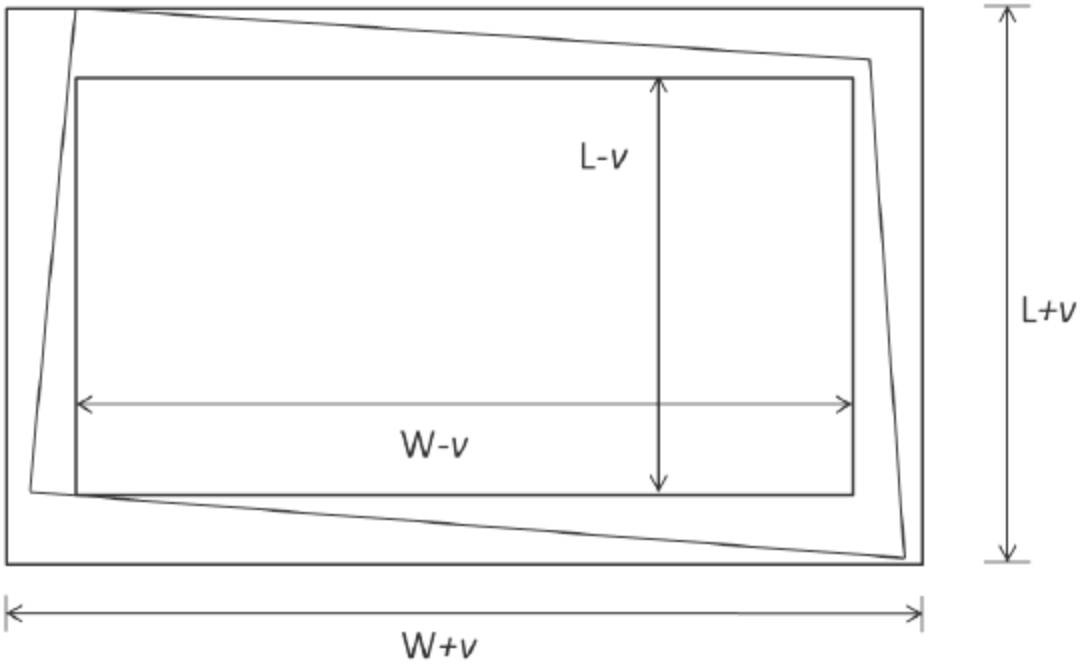


FIG. 3 DEVIATION LIMITS FOR DIMENSIONS OF RECTANGULAR PANES

Table 2 Deviation on Width and Length

(*Clause* 4.1.3)

Sl No.	Nominal Dimension *W* or *L*/*H*	Maximum Tolerance (*v*) on Nominal Dimensions
(1)	(2)	(3)
i)	≤ 2 000	≤ 3
ii)	≤ 3 000	≤ 4
iii)	> 3 000	≤ 5

NOTE — All dimensions are in mm.

4.1.4 *Edge Displacement*

The maximum displacement, d, shall be as specified in Table 3. Width (*W*) and length (*L*), shall be considered separately, (*see* Fig. 4).

NOTE — A suitable calibrated equipment, for example, caliper may be used to measure edge displacement.

4.1.5 *Light Stability Test*

It shall pass the requirements of light stability test as specified in **7.6** of IS 17004.

Table 3 Maximum Permissible Displacement for Laminated Safety Glass

(*Clause* 4.1.4)

Sl No.	Nominal Dimension, *W* or *L*	Maximum Permissible Displacement, *d*
(1)	(2)	(3)
i)	≤ 1 000	2.0
ii)	≤ 2 000	3.0
iii)	≤ 4 000	4.0
iv)	> 4 000	5.0

NOTE — All dimensions are in mm.

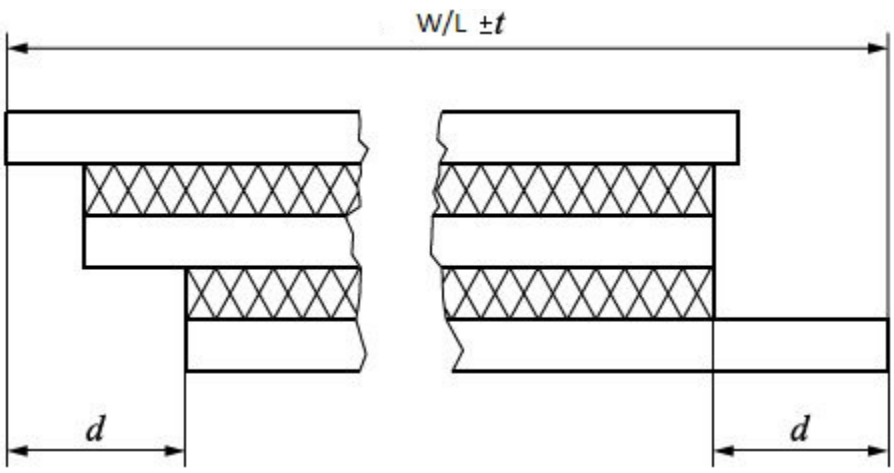


FIG. 4 EDGE DISPLACEMENT

4.1.6 *Bake Test*

When subjected to the bake test as prescribed in **7.1.2** of IS 17004, none of the three samples tested shall show any faults (bubbles, delamination, haziness and clouding) leaving 15 mm from an original edge and 20 mm from a cut edge of the specimen. In case only one test specimen develops faults in a particular test, draw another 3 samples from the lot and repeat the concerned test. No sample shall fail this time.

4.1.7 *Boil Test*

When subjected to the boil test as prescribed in **7.1.1** of IS 17004, none of the three samples tested shall show any faults (bubbles, delamination, haziness and clouding) leaving 15 mm from an original edge and 20 mm from a cut edge of the specimen. In case only one test specimen develops faults in a particular test, draw another 3 samples from the lot and repeat the concerned test. No sample shall fail this time.

4.1.8 *Defects in Central and Outer Area*

4.1.8.1 *Spot defects in the central area*

When examined according to the test method prescribed in **4.1.8.7**, the admissibility of spot defects (*see* Table 4) depends on the following:

a) Size of the defect;

b) Frequency of the defect;

c) Size of the pane; and

d) Number of panes as components of a laminated safety glass.

Defects less than 0.5 mm are not considered and defects greater than 3 mm are not permitted.

NOTE — Admissibility of spot defects in laminated glass is independent of the individual glass thickness.

The number of permissible defects in Table 4 shall be increased by 1 for each individual interlayer of thickness greater than 2 mm.

4.1.8.2 *Linear defects in the central area*

When inspected according to the test method given in **4.1.8.7**, linear defects shall conform to Table 5. Linear defects less than 30 mm in length are allowed.

4.1.8.3 *Defects in the outer area for framed edges*

When inspected according to the test method given in **4.1.8.7**, defects less than 5 mm in diameter are permitted in the outer area. If bubbles are present, the bubbled area shall not exceed 5 percent of the outer area.

4.1.8.4 *Vents*

Vents are not permitted.

4.1.8.5 *Creases and streaks*

These are not allowed in the central area.

4.1.8.6 *Defects on edge which will not be framed*

Laminated safety glass is usually installed in frames; when it is unframed, it may have:

a) Ground edges;

b) Polished edges; and

c) Bevelled edges.

Table 4 Permissible Spot Defects in Laminated Safety Glass in Central Area

(*Clause* 4.1.8.1)

Sl No.	**Size of Defect, d in mm →**		**0.5 < d ≤ 1.0**	**1.0 < d ≤ 3.0**			
	Size of Pane, A in m^2 →		**For All Sizes**	**A ≤ 1 (Total Number)**	**1 < A ≤ 2 (Total Number)**	**2 < A ≤ 8 (Number/m^2)**	**A > 8 (Number/m^2)**
(1)	(2)		(3)	(4)	(5)	(6)	(7)
i)	Number of permissible defects in	a) 2 panes	No limitation, however no accumulation of defects (*see* Note)	1	2	$1/m^2$	$1.2/m^2$
ii)		b) 3 panes		2	3	$1.5/m^2$	$1.8/m^2$
iii)		c) 4 panes		3	4	$2/m^2$	$2.4/m^2$
iv)		d) ≥ 5 panes		4	5	$2.5/m^2$	$3/m^2$

NOTE — If four or more defects are at a distance of < 200 mm from each other, it is termed as an accumulation of defects. This distance is reduced to 180 mm for laminated safety glass consisting of three panes, to 150 mm for laminated safety glass consisting of 4 panes and to 100 mm for laminated safety glass consisting of five or more panes.

Table 5 Number of Permissible Defects in Central Area

(*Clause* 4.1.8.2)

Sl No.	Area of Pane	Number of Permissible Defects ≥ 30 mm in Length
(1)	(2)	(3)
i)	≤ 5 m^2	Not allowed
ii)	5 m^2 to 8 m^2	1
iii)	> 8 m^2	2

In such conditions, shells, bubbles, interlayer defects and retractions are permissible if they do not become apparent when subjected to the test method prescribed in **4.1.8.7**.

4.1.8.7 *Test method*

The laminated safety glass specimen is put in a vertical position, in front of and parallel to a matt grey screen, lit by diffuse daylight or equivalent. The observer shall be at a distance of 2 m from the glass, observing it perpendicularly (the matt screen being on the other side of the glass). Defects that are disturbing when viewed shall be marked.

4.1.9 *Humidity Test*

Laminated safety glass shall be subjected to the humidity test as prescribed in **7.2** of IS 17004. In both these tests, none of the three samples tested shall show any faults (bubbles, delamination, haziness and clouding) leaving 15 mm from an original edge and 20 mm from a cut edge of the specimen. In case only one test specimen develops faults in a particular test, draw another 3 samples from the lot and repeat the concerned test. No sample shall fail this time.

4.1.10 *Additional Requirements for BRG for Automotive Applications*

The bullet resistant glass intended to be used for automotive applications shall be additionally tested for the requirements specified at **4.1.10.1** to **4.1.10.7**.

4.1.10.1 *Visual light transmittance, Min*

When tested as per the method prescribed in either **7.6.2.2** or **7.6.2.3** of IS 17004, the visual light transmittance values shall not be less than 70 percent in case of front and rear windscreens and 50 percent in case of side panes.

4.1.10.2 *Resistance to abrasion*

4.1.10.2.1 *Bullet resistant glass that does not include plastic glazing materials*

When tested in accordance with **6.6** of IS 2553 (Part 2) for 1 000 cycles, light scatter shall not exceed 2 percent.

4.1.10.2.2 *Bullet resistant glass that includes plastic glazing materials*

For glazing faced with plastic, when tested on the inner side in accordance with **6.6** of IS 2553 (Part 2) for 100 cycles, light scatter shall not exceed 4 percent.

4.1.10.3 *Optical distortion test*

4.1.10.3.1 When tested in accordance with **6.12** of IS 2553 (Part 2) optical distortion shall not exceed the values given in Table 6 for each zone or test area.

4.1.10.3.2 No measurements shall be made in a peripheral area 25 mm inboard of the design glass outline and of any opaque obscuration, provided that it does not impinge into the extended Zone A or Zone I.

NOTE — For more information on test areas and zones, please *see* **7.3** of IS 2553 (Part 2).

4.1.10.3.3 In the case of split windscreens, no measurements shall be made in a strip 35 mm from the edge of the windscreen which is adjacent to the dividing pillar.

4.1.10.3.4 A maximum value of 6' of arc is permitted for all portions of Zone I or Zone A in a peripheral area 100 mm inboard of the design glass outline.

4.1.10.3.5 *Test pieces*

Four windscreens shall be tested and each shall meet the requirements.

4.1.10.3.6 *Alternate test method*

Alternate test procedure of optical distortion test as prescribed in **6.12.6** of IS 2553 (Part 2) shall also be accepted.

4.1.10.4 *Secondary image separation test*

4.1.10.4.1 When tested in accordance with **6.13** of IS 2553 (Part 2), separation of the primary and secondary image shall not exceed the values given in Table 7 for each zone or test area.

4.1.10.4.2 No measurements shall be made in a peripheral area 25 mm inboard of the design glass outline and of any opaque obscuration, provided that it does not impinge into the extended Zone A or Zone I.

4.1.10.4.3 In the case of split windscreens, no measurements shall be made in a strip 35 mm from the edge of the glass pane which is to be adjacent to the dividing pillar.

4.1.10.4.4 A maximum value of 25' of arc is permitted for all portions of Zone I or Zone A in a peripheral area 100 mm inboard of the design glass outline.

4.1.10.4.5 *Test pieces*

Four windscreens shall be tested and each shall meet the requirements.

4.1.10.4.6 *Alternate test method*

Alternate test procedure of secondary image separation test as per **6.13.5** of IS 2553 (Part 2) shall also be accepted.

Table 6 Limits for Optical Distortion

(*Clause* 4.1.10.3.1)

Sl No.	Vehicle Category	Zone or Test Area	Maximum Values of Optical Distortion
(1)	(2)	(3)	(4)
i)	M1 and N (derived from a M1 where the windscreen and seating positions are identical)	A — extended according to **7.1.3.3.2** of IS 2553 (Part 2). Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	2' of arc
		B — reduced according to **7.1.3.3.4** of IS 2553 (Part 2). Alternatively, outer area as per **7.1.4** of IS 2553 (Part 2).	6' of arc
ii)	L Category (with bodywork, at least partially covering the driver)	Primary area as defined in IS 16325. Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	2' of arc
		Secondary area as defined in IS 16325. Alternatively, outer area as per **7.1.4** of IS 2553 (Part 2).	6' of arc
iii)	M2, M3 and N (except those N derived from a M1 where the windscreen and seating position are identical)	I according to **7.1.3.4.2** of IS 2553 (Part 2). Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	2' of arc

Table 7 Limit for Separation of Primary and Secondary Images

(*Clause* 4.1.10.4.1)

Sl No.	Vehicle Category	Zone or Test Area	Maximum Values of the Separation of the Primary and Secondary Images
(1)	(2)	(3)	(4)
i)	M1 and N (derived from a M1 where the windscreen and seating positions are identical)	A — extended according to **7.1.3.3.2** of IS 2553 (Part 2). Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	15' of arc
ii)		B — reduced according to **7.1.3.3.4** of IS 2553 (Part 2). Alternatively, outer area as per **7.1.4** of IS 2553 (Part 2).	25' of arc
iii)	L Category (with bodywork, at least partially covering the driver)	Primary area as defined in IS 16325. Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	15' of arc
iv)		Secondary area as defined in IS 16325. Alternatively, outer area as per **7.1.4** of IS 2553 (Part 2).	25' of arc
v)	M2 , M3 and N (except those N derived from a M1 where the windscreen and seating position are identical)	I according to **7.1.3.4.2** of IS 2553 (Part 2). Alternatively, central area as per **7.1.4** of IS 2553 (Part 2).	15' of arc

4.1.10.5 *Resistance to temperature change*

Two samples of 300 mm × 300 mm shall be placed in temperature of - 45°C to - 35°C for 6 hours. Then placed in still air of temperature 22 °C to 24 °C for 1 hour. The specimens shall be then placed in circulating air temperature of 70 °C to 74 °C for 3 hours. After the test, when examined none of the test piece shall show any evidence of deterioration such as cracking, clouding or delamination.

4.1.10.6 *Test for resistance to fire*

When tested in accordance with **6.14** of IS 2553 (Part 2), the rate of burning for safety glazing faced with plastics material and glass-plastics shall not exceed 90 mm/min. Five test pieces shall be tested and each shall meet the requirements. The test pieces shall be as described in **6.14.3** of IS 2553 (Part 2).

4.1.10.7 *Test for resistance to chemical*

When tested in accordance with **6.15** of IS 2553 (Part 2), the test piece shall not exhibit any softening, tackiness, crazing, or apparent loss of transparency. Four test pieces per chemical shall be tested and at least three shall meet the requirements. The test pieces shall be as described in **6.15.3** of IS 2553 (Part 2).

4.2 Ballistic Performance Requirements

The ballistic performance tests will be conducted only when quality requirements specified in **4.1** are satisfied.

The specimen shall be tested according to the method prescribed in Annex A and the level of bullet resistance (*see* Table 8) and spalling (*see* **A-5**) of the specimen shall be determined.

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: (– 40 ± 5) °C or (70 ± 5) °C, and the test shall be conducted according to Annex B and the level of bullet resistance (*see* Table 8) and spalling (*see* **A-5**) of the specimen shall be determined.

NOTE — The performance requirements specified in **A-5** are known to apply only to glass laminates. When materials other than glass laminates are being tested, additional tests shall be conducted to establish the relative penetrative resistance in relation to the classifications.

5 PACKING AND MARKING

5.1 Packing

5.1.1 Bullet resistant security glazing shall be packed as agreed to between the manufacturer and the purchaser.

5.1.2 The packet shall be marked with the following information:

a) Indication of the source of manufacture;
b) Nominal thickness of glass;
c) Code or batch number; and
d) Month and year of manufacture.

5.2 Marking

5.2.1 Each piece of safety glass shall be marked indelibly and distinctly with the following information:

a) Level of bullet resistance and spalling (delible);
b) Strike face (delible);
c) Indication of the source and year of manufacture; and
d) Code or batch number.

5.2.2 *BIS Certification Marking*

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

6 SAMPLING AND CRITERIA FOR CONFORMITY

Representative samples of the material shall be drawn as prescribed in Annex C. Perforation (*see* **3.14**) in any of the test sample is not allowed during the ballistic evaluation.

7 TEST REPORT

It shall clearly indicate the following information:

a) The description of the test specimen;
b) Location of the test and date of the test;
c) Reference to this standard with year;
d) Date of the test report issuance; and
e) Temperature during the sample conditioning and temperature during the test.

In addition to the above, in case of ballistic testing, the test report shall clearly indicate the following information also:

a) Threat level achieved;
b) Weapon and ammunition used;
c) Sample photographs before and after the test – strike face and rear face; and
d) Photographs of witness sheet before and after the test.

ANNEX A

(*Clause* 4.2)

TEST METHOD FOR EVALUATION OF BULLET RESISTANCE

A-1 THREAT LEVELS

A-1.1 The test ammunitions specified in this standard represent the most frequently faced threats and are classified into 6 threat levels given in Table 8.

A-1.2 Launching systems shall preferably be test barrels, however weapons can also be used to achieve reference velocities.

A-1.3 All ammunition should be specified with head stamp details. Testing agency may use re-loaded ammunition to meet the velocity requirements. However complete details of the propellants, cartridge cases, storage, and propellant charge verses mass details shall be made available to other laboratories to ensure repeatability of test results. All relevant details shall be clearly mentioned in the test report.

A-2 BALLISTIC EVALUATION

A-2.1 Test Specimen

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

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

A-2.2 Test Layout

The test range shall be setup as per Fig. 5. Threat level 1 shall be tested from a distance of 5 m from the strike face of test specimen. Threat levels 2 and above shall be tested at a distance of 10 m from the strike face of test specimen.

A-2.3 Test Setup

The test setup (*see* Fig. 5) shall consist of the following:

A-2.3.1 *Rigid Frame*

The preconditioned test specimen shall be mounted in a frame, along the full length of all four edges, with a minimum sight size 440 mm × 440 mm. The frame shall be provided with a clamping plate to hold the glazing in position and means for producing uniform clamping of the bullet resistant glass.

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

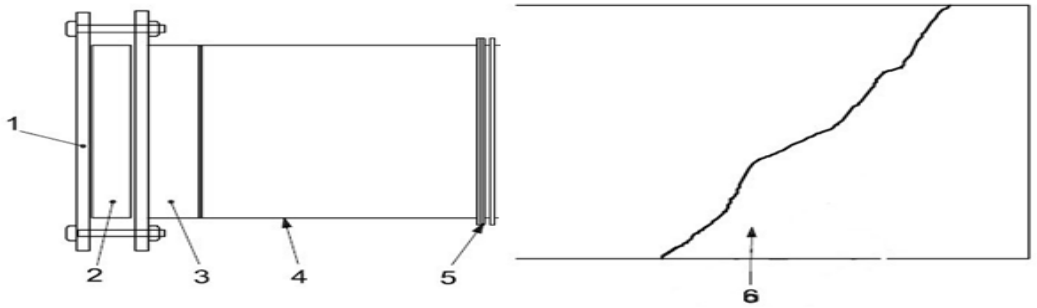
a) The test specimen shall have an edge cover of not less than 25 mm on all edges;

b) The test specimen shall be separated from the frame and the clamping plate by continuous rubber strips of uniform thickness on all sides;

c) All four edges of the test specimen shall be uniformly secured from all the sides so that the edges remain in position during the test; and

d) The test specimen in the frame shall be placed normal to the direction of attack.

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.



Key

1 clamping plate
2 glazing
3 rigid frame
4 splinter-collecting box
5 witness sheet
6 bullet and debris stop

FIG. 5 TEST-SETUP

A-2.3.2 *Splinter-Collecting Box* (*Optional*)

A splinter-collecting box shall be mounted between the rigid frame and the witness sheet. The splinter-collecting box should have an opening of at least 440 mm × 440 mm that matches the sight size of the glazing and should fully enclose the gap between the frame and the witness sheet. The splinter-collecting box should extend beyond the witness sheet 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 sheet for visual inspection. It is not intended to arrest all bullets which can pass through targets at high velocity.

A-2.3.3 *Witness System*

The witness system shall consist of a 0.5 mm thick aluminum alloy sheet for Ex. T6061 aluminum alloy, mounted parallel to the test specimen, with a clear surface of at least 440 mm × 440 mm that matches the sight size of the glazing. The witness sheet shall be at a distance of 150 mm ± 10 mm behind the test specimen.

A-2.3.4 *Velocity Measuring Equipment*

Preferably non-contact type discrete velocity screens or Doppler radar shall be used. Discrete velocity measurement screens shall be centered at 2.5 m ± 0.025 m from the strike face of the test specimen. Velocity of projectile at 2.5 m from the strike face of test specimen shall be reported as strike velocity. Personnel conducting ballistic testing shall be properly trained in velocity measurement systems and Doppler radars. The fineness unit for rounding off velocity data shall be 0.1.

A-2.3.5 *Weapon Systems*

Weapon systems shall preferably be test barrels, however conventional weapons may also be used to achieve velocities. The testing agency shall display complete work instructions related to setup and maintenance of the weapons prominently near the weapon stand. Remote triggering shall be preferably used. Reports shall clearly mention whether weapons or test barrels were used along with their registration numbers.

A-2.3.6 *Target Stand*

The target stand shall preferably have provision for X-Y-Z movement.

A-2.3.7 *Bullet and Debris Stop*

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

A-3 CLASSIFICATION OF BULLET RESISTANCE

Table 8 Threat Levels

(*Clause* 4.2, A-1.1, A-4.1 *and* C-3)

Sl No.	Threat Level	Ammunition	Bullet weight	Bullet Type	Strike Velocity	Distance of Impact	No. of Strikes	Remarks
			(*g*)		(m/s)	(m)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	1	9 mm × 19 mm	7.4 to 8.2	FMJ/Pb	430 ± 15	5 ± 0.5	5	–
ii)	2	7.62 mm × 39 mm	7.45 to 8.05	FMJ/ MSC	710 ± 15	10 ± 0.5	5	–
iii)	3	7.62 mm × 51 mm	9.4 to 9.6	FMJ/Pb	838 ± 15	10 ± 0.5	5	plus compliance with Level 2
iv)	4	5.56 mm × 45 mm	3.5 to 4.0	FMJ/(SI + Pb)	890 ± 15	10 ± 0.5	5	plus compliance with Level 3
v)	5	7.62 mm × 39 mm	7.45 to 8.05	HSC	700 ± 15	10 ± 0.5	5	plus compliance with Level 3
vi)	6	7.62 mm × 54 mm	10.3 to 10.5	API	830 ± 15	10 ± 0.5	1	–
vii)	Special *	Any other requirement by the user. Complete details of ammunition shall be stored for future upgradation of the standard						

*For special threat levels, the bullet velocity specified for the test should be representative of that developed by the weapon and ammunition, preferably at the higher end of the range of possible velocities. The range selected should be sufficient to enable the bullet flight to stabilize.

A-4 PROCEDURE

A-4.1 The weapon and ammunition shall be selected from Table 8 according to the level of bullet-resistance required. The test specimen shall be mounted in the frame and positioned at the appropriate distance from the muzzle of the weapon according to Table 8.

A-4.2 Fair Hit Criteria

Unless specified otherwise, a shot is considered fair hit if it impacts the panel and meet the following criteria:

a) Edge to shot distance:
   1) At a minimum distance of 51 mm; and
   2) At less than 51 mm from edge but does not cause perforation in test piece or witness sheet and pass appropriate spall performance (*see* **A-5**).

b) Shot distance from a prior shot:
   1) At a minimum distance of 51 mm; and
   2) At less than 51 mm distance from the prior shot but does not cause perforation in test piece or witness sheet and pass appropriate spall performance (*see* **A-5**).

c) At a velocity within the specified range;

d) At a velocity less than the specified range and cause perforation in test piece or witness sheet; and

e) At a velocity more than the specified range and/or less than inter-shot distance and does not cause perforation in test piece or witness sheet and pass appropriate spall performance (*see* **A-5**).

Unless specified otherwise, in case of an even a single unfair hit, the test specimen shall be discarded and a fresh test specimen shall be taken for evaluation.

A-4.3 Shot Locations

Unless specified otherwise, the glazing shall be tested with five shots for threat levels from 1 to 5 and single shot for threat Level 6.

All Shots shall meet the edge to shot and shot to shot distance requirements as given in **A-4.3**. Shot sequence for shots from 1 to 4 may be clock-wise or anti clock-wise but no shot shall be diagonally opposite to the prior shot. 5th shot shall be fired in centre of the rest four shots.

The test specimen shall be examined for any perforation between strike and rear face. Perforation of the glazing shall be determined by:

a) the presence of openings between the strike face and the rear face, or

b) the presence of fragments of bullet in the splinter-collecting box.

A-4.4 The witness sheet shall be inspected against a 60 W bulb to determine if there are any perforations, after lightly brushing to remove any adherent particles.

A-4.5 The validity of the test shall be determined in accordance with **A-5**.

A-5 SPALLING

The test specimen shall conform to at least one of the following:

A-5.1 Spall (S)

No perforation of the glazing, but with perforations in the witness sheet;

A-5.2 Reduced Spall (RS)

No perforation of the glazing, with loss of material from the non-attack surface but no perforations in the witness sheet;

A-5.3 No Spall (NS)

No perforation of the glazing, with no loss of material from the non-attack surface and no perforations in the witness sheet.

If there is *perforation* (*see* **3.14**) in the test specimens, the glazing cannot be classified at the level tested.

If the test specimen meets only the requirement **A- 5.1**, then the classification is given the additional letter “S” (spalling).

If the test specimen meets the requirement **A-5.2**, then the classification is given the additional letter “RS” (reduced spalling).

If the test specimen meets requirement **A-5.3**, then the classification is given the additional letter “NS” (no spalling).

Routine ballistic evaluation may use service ammunition where bullet weight is not considered. Bullet weight shall be considered for reloaded ammunitions.

FMJ:	Full Metal Jacket	Pb:	Lead Core
MSC:	Mild Steel Core	SI:	Steel Insert
HSC:	Hard Steel Core	API:	Armour Piercing Incendiary

ANNEX B

(*Clause* 4.2)

EVALUATION OF BULLET RESISTANCE AT EXTREME TEMPERATURES

(*OPTIONAL*)

B-1 APPLICATION

The influence of the outside temperature should be considered when glazing is intended for use under extreme conditions. Separate samples shall be taken for high and low temperature tests. This test is optional and shall be conducted as per user requirements.

B-2 Low Temperature Conditioning

The test pieces should be stored for (12 h ± 30 min) at (- 40 ± 5) °C before ballistic evaluation. First shot shall be fired within 10 min and ballistic testing shall be completed within 40 min, after removing from the extreme temperature.

B-3 High Temperature Conditioning

The test pieces should be stored for (12 h ± 30 min) at (70 ± 5) °C before ballistic evaluation. First shot shall be fired within 10 min and ballistic testing shall be completed within 40 min, after removing from the extreme temperature.

ANNEX C

(*Clause* 6)

SAMPLING AND CRITERIA FOR CONFORMITY

C-1 LOT

For all the bullet resistant safety glasses of the same nominal thickness manufactured using similar type and thickness of interlayer by the same process under similar conditions in a day shall constitute one lot.

C-2 The conformity of lot to the requirements of standard shall be determined based on the test carried out on samples selected from it.

C-3 The sampling plan as described in Table 9 shall be followed for the various tests to be performed as per the quality requirements of BRG as mentioned in **4.1**. And for ballistic performance requirements, the sampling plan as prescribed in Table 10 shall be followed. In order to ensure the randomness of selection, procedure given in IS 4905 may be followed.

NOTES

1 The Table 10 is based on the IS 2500 (part 1) and special inspection level S4.

2 In case where threat levels (*see*, Table 8) comprises of prior evaluation with other threat levels (such as threat level 5 requires evaluation of threat Level 3 also), the no. of samples given in the col (3) of Table 10 shall be divided equally to evaluate the conformity with each threat level).

C-4 Sizes of the test specimen listed in col (4) of Table 9 are recommended in view of the limitation of size of specimen that can be accommodated by the respective test equipment. Test specimen shall be prepared simultaneously along with the product, under similar conditions using similar raw material, that is glass and interlayer as used to manufacture the BRG.

C-5 CRITERIA FOR CONFORMITY

The acceptance criteria for quality requirements of BRG is given at col (5) of Table 9. For ballistic performance requirements of BRG, there shall be no perforation (*see* **3.14**) in any of the sample tested.

Table 9 Sample Size and Criteria for Conformity for Quality Requirements of BRG

(*Clause* C-3, C-4 *and* C-5)

Sl No.	Testing Parameters	No. of Samples	Size of Samples	Acceptance Criteria
(1)	(2)	(3)	(4)	(5)
i)	Thickness	5 percent of the quantity from each size, but not less than five safety glasses.	Actual size of product	All samples shall pass. In case of any single failure, draw another 5 percent and repeat the test. None of these samples shall fail.
ii)	Dimensions and squareness			
iii)	Edge displacement			
iv)	Light stability test	3	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
v)	Bake test	3	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
vi)	Boil test	3	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.

Table 3 (*Concluded*)

Sl No.	Testing Parameters	No. of Samples	Size of Samples	Acceptance Criteria
(1)	(2)	(3)	(4)	(5)
vii)	Defects in the central area	3	Actual size of product	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
viii)	Humidity test	2 pair of 3 samples	300 mm × 300 mm	All three samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
ix)	Light transmittance, *Min* NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	3	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
x)	Resistance to abrasion NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	3	100 mm × 100 mm	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
xi)	Optical distortion test NOTE — Applicable only in case the glass is intended to be used as windscreens.	4	Actual size of product	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
xii)	Secondary image separation test NOTE — Applicable only in case the glass is intended to be used as windscreens.	4	Actual size of product	All samples shall pass. In case of any single failure, draw another 3 samples from the lot and repeat the test. None of these 3 samples shall fail.
xiii)	Resistance to temperature change NOTE — Applicable only in case the glass is intended to be used for automotive vehicles.	2	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 2 samples from the lot and repeat the test. None of these 2 samples shall fail.
xiv)	Resistance to fire test NOTE — Applicable only in case the glass is intended to be used for automotive vehicles and having an anti-spall (plastic) film.	2	300 mm × 300 mm	All samples shall pass. In case of any single failure, draw another 2 samples from the lot and repeat the test. None of these 2 samples shall fail.
xv)	Resistance to chemical test NOTE — Applicable only in case the glass is intended to be used for automotive vehicles and having an anti-spall (plastic) film.	2	180 mm × 25 mm	All samples shall pass. In case of any single failure, draw another 2 samples from the lot and repeat the test. None of these 2 samples shall fail.

Table 10 Sample Size for Ballistic Performance Requirements of BRG

(*Clause* C-3)

Sl No.	Lot Size	No. of Samples
(1)	(2)	(3)
i)	2 to 15	2
ii)	16 to 25	3
iii)	26 to 90	5
iv)	91 to 150	8
v)	151 to 500	13
vi)	501 to 1 200	20
vii)	1 201 to 10 000	32
viii)	10 001 to 35 000	50
ix)	35 001 to 500 000	80
x)	500 001 and over	125

ANNEX D

(*Foreword*)

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