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Indian Standard

IS 2553 (Part 2) : 2019

सुरक्षा काँच — विशिष्टि

भाग 2 सड़क परिवहन के लिए

(पहला पुनरीक्षण)

Safety Glass — Specification

Part 2 For Road Transport

(First Revision)

ICS 43.040.65

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Body, Chassis, Accessories, Garage Equipment, Springs and Suspension Systems Sectional Committee had been approved by the Transport Engineering Division Council.

This standard specifies the requirements for safety glazing intended for installation in motor vehicles. Its purpose is:

a) to reduce the danger of bodily injury as far as possible in the event of shattering of a vehicle window;
b) to ensure that vehicle windows are sufficiently resistant to the incidents likely to occur in normal traffic, and to atmospheric and temperature conditions, chemical action, combustion and abrasion;
c) to ensure that windscreens are sufficiently transparent to ensure driver visibility and to allow the driver to see the road clearly enough to be able to brake and stop the vehicle in the event of windscreen shattering; and
d) to minimize the possibility of occupants being thrown through vehicle windows in collisions.

This standard was first published as IS 2553 (Part 2) : 1992 'Safety glass — Specification: Part 2 For road transport'. This revision has been undertaken as part of UN GTR Alignment of various Indian Standards. This standard has been aligned with the requirements of UN GTR 6 (upto Amendment 1). Assistance was also taken from UN Regulation 43 wherever required since UN GTR Transposition to the UN R 43 was complete up to Amendment 1 of UN GTR 6.

In the Contemporary Automotive Industries, various types of Safety Glazing materials are being used globally. Some new types of Glazing are also introduced in this standard. These are Laminated Glass with Plastic Face, Treated Laminated Glass, Glass Plastics, Toughened Glass with Plastic Face, Double Glazed Unit. Since Plastics is introduced as new type of glazing, this requires some additional tests to be conducted on them. These additional tests are Abrasion Test, Humidity Test, and Resistance to Temperature Change Test, Resistance to Fire Test and Resistance to Chemical Test. In future, those glazing which are exposed to plastic surface may be used on vehicle, for this reason some safety, quality and performance tests are introduced.

In the preparation of this standard considerable assistance has been derived from following documents:

ECE/TRANS/WP.29/AC.3/9 & ECE/TRANS/WP29/1047 and the following publications:

UN R43 — Uniform Provisions for Concerning the Approval of Safety Glazing Materials and their Installation on Vehicles.

UN GTR 6 — Safety Glazing Materials for Motor Vehicles and Motor Vehicles Equipments.

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 : 1960 'Rules for rounding off numerical values (*revised*)'. 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

SAFETY GLASS — SPECIFICATION

PART 2 FOR ROAD TRANSPORT

(First Revision)

1 SCOPE

This standard applies to safety glazing intended for installation as windscreens, window panes on Category M, N, A (fitted with cabin), C (fitted with cabin), Combine Harvester and L (with bodywork at least partially covering the driver) vehicles as defined in IS 14272 : 2011 'Automotive vehicles — Types — Terminology' concerning the Classification of vehicles to the exclusion of glazing for lighting and light-signaling devices and instrument panels, glazing which are fitted on the body for aesthetic purpose and are not in driver's forward or rearward field of vision, plastic windows of soft top vehicles and bullet resistant glazing. In the case of double windows, each pane is considered a separate item of glazing.

2 REFERENCES

The following standards 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 the standards indicated below.

IS No.	*Title*
14272 : 2011	Automotive vehicles — Types — Terminology (*first revision*)
2553 (Part 1) : 1990	Safety glass : Part 1 For general purposes (*third revision*)
13749 : 2009	Automotive vehicles — Procedure for determining the 'H' point and the torso angle for 50th percentile adult male in seating positions of motor vehicles
16325 : 2019	Automotive vehicles — Windscreen wiping system for 3 wheeler vehicles — Specification

3 DEFINITIONS

3.1 Bullet Resistant Glazing — Glazing constructed so as to be resistant to firearms.

3.2 Design Glass Outline — The design maximum unobstructed vehicle aperture designated to be glazed, before the glazing is installed or mounted, including all trims, but excluding obscuration bands.

3.3 Glazing — The following materials for purposes of this standard:

3.3.1 *Double-Glazed Unit* — An assembly of two panes permanently assembled in manufacture and separated by a gap.

3.3.1.1 *Symmetrical Double-Glazed Unit* — A double-glazed unit where the two component panes are identical (for example, both toughened glass).

3.3.1.2 *Asymmetrical Double-Glazed Unit* — A double-glazed unit where the two component panes are not identical (for example, one is toughened glass and the other is laminated glass).

3.3.2 *Double Window* — An assembly of two individual panes separately installed within the same opening in the vehicle.

3.3.3 *Glass-Plastics* — Glazing consisting of any glazing material which comprises one layer of glass and one or more layers of plastic in which a plastic surface of the product faces the inner side.

3.3.4 *Interlayer* — Any material designed to be used to hold together the component layers of laminated-glass.

3.3.5 *Laminated-Glass* — Glazing consisting of two or more layers of glass held together by one or more inter-layers of plastic material.

3.3.6 *Glazing Faced with Plastics* — A glass pane either toughened-glass or laminated-glass with a layer of plastic on the inner side.

3.3.7 *Uniform Toughened Glass* — Glazing consisting of a single layer of glass which has been subjected to special treatment to increase its mechanical strength and to condition its fragmentation after shattering.

3.3.8 *Plastic Glazing* — Glazing material that contains as an essential ingredient one or more organic polymeric substances of large molecular weight, is solid in its finished state and, at some stage in its manufacture of processing into finished articles, can be shaped by flow.

3.3.8.1 *Rigid Plastic Glazing* — A plastic glazing material which does not deflect vertically more than 50 mm in the flexibility test.

3.3.8.2 *Flexible Plastic Glazing* — A plastic glazing material which deflects vertically more than 50 mm in the flexibility test.

3.4 Glazing Requisite for Driver Visibility

3.4.1 *Glazing Requisite for the Driver's Forward Field of Vision* — All the glazing forward of a plane passing through the driver's 'R' point and perpendicular to the longitudinal median plane of the vehicle, through which the driver is able to view the road when driving or manoeuvring the vehicle.

3.4.2 *Glazing Requisite for the Driver's Rearward Field of Vision* — All glazing rearward of a plane passing through the driver's 'R' point and perpendicular to the longitudinal median plane of the vehicle, through which the driver is able to view the road when driving or maneuvering the vehicle.

3.5 Height of Segment 'h' — The maximum distance, measured at right angles to the glazing, separating the inner surface of the glazing from a plane passing through the ends of the glazing (*see* **7.2**, Fig. 37).

3.6 Inner Side — The side of glazing which is facing towards the passenger/driver compartment when the material is mounted in the vehicle.

3.7 Nominal Thickness — The manufacturer's design thickness with a tolerance of ± (n × 0.2 mm) where n equals the number of glass layers in the glazing.

3.8 Opaque Obscuration — Any area of the glazing preventing light transmission, including any screen-printed area, whether solid or dot-printed, but excluding any shade band.

3.9 Optical Deviation — The angle between the true and the apparent direction of a point viewed through the windscreen, the magnitude of the angle being a function of the angle of incidence of the line of sight, the thickness and inclination of the windscreen, and the radius of curvature '*r*' at the point of incidence.

3.10 Optical Distortion — An optical defect in a windscreen that changes the appearance of an object viewed through the windscreen.

3.11 Outer Side — The side of glazing which is facing away from the passenger/ driver compartment when the material is mounted in the vehicle.

3.12 Pane — Any single piece of glazing other than a windscreen.

3.12.1 *Curved Pane* — A pane with a height of segment '*h*' (*see* **7.2**) greater than 10 mm per linear metre.

3.12.2 *Flat Pane* — A pane with a height of segment '*h*' (*see* **7.2**) equal to or less than 10 mm per linear metre.

3.13 Reference Points

3.13.1 *Eye-Point* — The 'O' Point.

3.13.2 '*H*' *Point* — The pivot centre of the torso and thigh of the 3 DH machine installed in the vehicle seat. The 3 DH machine corresponds to that described in IS 13749. The coordinates of the H point are determined in relation to the fiducial marks defined by the vehicle manufacturer, according to the three-dimensional system corresponding to IS 13749.

3.13.3 '*O*' *Point* — The point located 625 mm above the "R" point of the driver's seat in the vertical plane parallel to the longitudinal median plane of the vehicle for which the windscreen is intended, passing through the axis of the steering wheel.

3.13.4 *'R' Point or Seating Reference Point* — The position of the H-point with the driver's seat in the design driving position as defined by the vehicle manufacturer.

3.13.5 *Design Seat-Back Angle* — The angle between the vertical line through the 'R' point and the torso line defined by the vehicle manufacturer.

3.14 Radius of Curvature '*r*' — The smallest radius of arc of the glazing as measured in the most curved area.

3.15 Regular Light Transmittance — Light transmittance measured perpendicularly to the glazing.

3.16 Sample — A specially prepared piece of glazing representative of a finished product or a piece cut from a finished product.

3.17 Secondary Image — A spurious or ghost image, in addition to the bright primary image, usually seen at night when the object being viewed is very bright in relation to its surroundings, for example, the headlights of an approaching vehicle.

3.18 Secondary Image Separation — The angular distance between the position of the primary and secondary images.

3.19 Shade Band — Any area of the glazing with a reduced light transmittance, excluding any opaque obscuration.

3.20 Test Piece — A sample or a finished product of glazing.

3.21 Transparent Area of the Windscreen — The glazing area contained within the design glass outline, excluding any allowed opaque obscuration (*see* **7.1.3.3**), but including any shade band.

3.22 Windscreen — The glazing in front of the driver through which the driver views the road ahead.

3.22.1 *Inclination Angle of a Windscreen* — The angle included between a vertical line and a straight line

passing through the top and bottom edges of the inner side of the windscreen, when both lines are contained in the vertical plane through the longitudinal axis of the vehicle.

3.23 Type of Safety Glazing Material — A glazing not exhibiting any essential differences, with respect, in particular, to the principal and secondary characteristics.

3.23.1 Although a change in the principal characteristics implies that the product is of a different type, it is recognized that in certain cases a change in shape and dimension does not necessarily require a complete set of tests to be carried out. For certain of the tests prescribed in this standard, glazings may be grouped if it is evident that they have similar principal characteristics.

3.23.2 Types of glazing exhibiting differences only as regards their secondary characteristics may be deemed to be of the same type; certain tests may however be carried out on samples of such glazings if the performance of those tests is explicitly stipulated in the test condition.

4 GENERAL REQUIREMENTS

4.1 Markings

4.1.1 *General Requirements for Markings*

4.1.1.1 All marking shall be clearly legible from at least one side of the glazing, indelible, and at least 2.6 mm in height.

4.1.2 *Identification Marks*

Each piece of glazing shall bear the appropriate marks set out in this section.

4.1.2.1 *Identification marks for windscreens*

4.1.2.1.1 "II" for laminated-glass.

4.1.2.1.2 "IV" for glass-plastics.

4.1.2.2 *Identification marks for panes*

4.1.2.2.1 'No symbol is required' for uniformly toughened glass.

4.1.2.2.2 "XI" for laminated glass.

4.1.2.2.3 "VI" for a double glazed unit.

4.1.2.2.4 "XII" for glass-plastics.

4.1.2.2.5 "VIII" for Rigid Plastic Glazing. In addition, the appropriate application will be signified by:

/A for forward facing panels

/B for Side, rear and roof glazing

/C In locations where there is little or no chance of head impact

In addition, for Plastic Glazing which has been submitted to the abrasion resistance tests described in **6.6** the following markings shall also be applied as appropriate:

/L for panes with a light scatter not exceeding 2percent after 1000 cycles on the outer surface and 4 percent after 100 cycles on the inner surface

/M for panes with a light scatter not exceeding 10 percent after 500 cycles on the outer surface and 4 percent after 100 cycles on the inner surface.

4.1.2.2.6 "IX' for flexible plastic glazing

4.1.2.3 Additional *Identification Marks*

4.1.2.3.1 Glazing faced with plastic shall be marked with "/P" after the mark required by **4.1.2.1** or **4.1.2.2**, for example, II/P.

4.1.2.3.2 Glazing with a light transmission of less than 70 per cent shall be marked with "V" the mark required by **4.1.2.2.**

4.1.2.3.3 If glazing requires both the "/P" and the "/V", the mark required by **4.1.2.3.1** shall precede the mark required by **4.1.2.3.2**.

5 PERFORMANCE REQUIREMENTS

Summary of performance requirements is given in Table 1.

5.1 Requirements Applicable to All Glazing

5.1.1 Light *Transmittance Test*

5.1.1.1 When tested in accordance with **6.11**, the regular light transmittance of glazing requisite for the Driver's Forward Field of Vision shall not be less than 70 percent.

5.1.1.2 When tested in accordance with **6.11**, the regular light transmittance of glazing requisite for the Driver's Rearward Field of Vision shall not be less than 50 percent.

5.1.1.3 *Test pieces*

5.1.1.3.1 Three test pieces shall be tested and each shall meet the requirements.

5.1.1.3.2 The test pieces shall be as described in **6.11.3**.

5.1.2 *Test of Resistance to Abrasion*

5.1.2.1 Except as provided in **5.1.2.2**, when tested in accordance with **6.6** for 1 000 cycles, light scatter shall not exceed 2 percent.

5.1.2.2 For glazing faced with plastic, when tested on the inner side in accordance with **6.6** for 100 cycles, light scatter shall not exceed 4 percent.

Table 1 Summary of Performance Requirements
(*Clause* 5)

	Windscreens			Panes							
	Laminated Glass		Glass Plastics	Uniformly Toughened Glass		Laminated Glass		Double Glazed Unit [1]	Glass Plastics	Rigid Plastic	Flexible Plastic
Marking	II	II/P	IV		P	XI	XI/P	VI	XII	VIII	IX
Light Transmittance	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**
Resistance to Abrasion	**5.1.2**	**5.1.2**	**5.1.2**		**5.1.2**	**5.1.2**	**5.1.2**		**5.1.2**	**5.1.2**	
Resistance to Temperature Changes		**5.2.1**	**5.2.1**		**5.2.1**		**5.2.1**		**5.2.1**		
Resistance to Fire		**5.2.2**	**5.2.2**		**5.2.2**		**5.2.2**		**5.2.2**	**5.2.2**	**5.2.2**
Resistance to Chemicals		**5.2.3**	**5.2.3**		**5.2.3**		**5.2.3**		**5.2.3**	**5.2.3**	**5.2.3**
Resistance to Radiation	**5.3.1**	**5.3.1**	**5.3.1**		**5.3.1**	**5.3.1**	**5.3.1**		**5.3.1**		
Resistance to High Temperature	**5.3.2**	**5.3.2**	**5.3.2**		**5.3.2**	**5.3.2**	**5.3.2**		**5.3.2**		
Resistance to Humidity	**5.3.3**	**5.3.3**	**5.3.3**		**5.3.3**	**5.3.3**	**5.3.3**		**5.3.3**	**5.3.3**	
Optical Distortion	**5.4.1**	**5.4.1**	**5.4.1**								
Image Separation	**5.4.2**	**5.4.2**	**5.4.2**								
Fragmentation				**5.5.1.1**	**5.5.1.1**						
Head-form[2]	**5.4.3**	**5.4.3**	**5.4.3**					**5.5.3.2**		**5.6.1**	
2.260 g Ball	**5.4.4**	**5.4.4**	**5.4.4**								
227 g Ball	**5.4.5**	**5.4.5**	**5.4.5**	**5.5.1.2**	**5.5.1.2**	**5.5.2.1**	**5.5.2.1**		**5.5.2.1**	**5.6.2**	**5.7.1**
Flexibility and Fold										**5.6.3**	**5.7.2**
Weathering										**5.6.4**	**5.6.4**
Cross-cut										**5.6.5**	

[1] Each component pane shall satisfy the appropriate tests for the type of glazing.
[2] This test is optional for 'L' category of vehicles.

5.1.2.3 For Rigid Plastic glazing, when tested in accordance with **6.6** for 1 000, 500 or 100 cycles to measure abrasion of the surface of the product.

5.1.2.3.1 In case of Rigid Plastics of Class L, the abrasion test shall be considered to have given a satisfactory result if the total light scatter after abrasion does not exceed 2 percent after 1 000 cycles on the outer surface of the test sample and 4 percent after 100 cycles on the inner surface of the test sample.

5.1.2.3.2 In case of Rigid Plastics of Class M, the abrasion test shall be considered to have given a satisfactory result if the total light scatter after abrasion does not exceed 10 percent after 500 cycles on the outer surface of the test sample and 4 percent after 100 cycles on the inner surface of the test sample.

5.1.2.4 *Test pieces*

5.1.2.4.1 Three test pieces shall be tested and each shall meet the requirements.

5.1.2.4.2 The test pieces shall be as described in **6.6.3**.

5.2 Requirements Applicable to All Glazing Faced with Plastic

5.2.1 *Test of Resistance to Temperature Changes*

5.2.1.1 When tested in accordance with **6.10** the test pieces shall not show any evidence of cracking, clouding, separation of layers or apparent deterioration.

5.2.1.2 *Test Pieces*

5.2.1.2.1 Two test pieces shall be tested and each shall meet the requirements.

5.2.1.2.2 The test pieces shall be as described in **6.10.2**.

5.2.2 Test *of Resistance to Fire*

5.2.2.1 When tested in accordance with **6.14**, the rate of burning for:

a) safety glazing faced with plastics material and glass-plastics shall not exceed 90 mm/min.
b) rigid plastic glazing, flexible plastic glazing and rigid plastic double glazed units shall not exceed 110 mm/min.

5.2.2.2 Test *Pieces*

Five test pieces shall be tested and each shall meet the requirements. The test pieces shall be as described in **6.14.3**.

5.2.3 *Test of Resistance to Chemicals*

5.2.3.1 When tested in accordance with **6.15**, the test piece shall not exhibit any softening, tackiness, crazing, or apparent loss of transparency.

5.2.3.2 *Test Pieces*

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**.

5.3 Requirements Applicable to All Laminated-Glass and All Glazing Faced with Plastics, Glass Plastics

5.3.1 *Test of Resistance to Radiation*

5.3.1.1 When tested in accordance with **6.8**, the total light transmittance when measured pursuant to **6.11** shall not fall below 95 percent of the original value before irradiation and for glazing required to have a minimum light transmittance of 70 percent, shall not fall below 70 percent.

5.3.1.2 *Test pieces*

Three test pieces shall be tested and each shall meet the requirements.The test pieces shall be as described in **6.8.3**.

5.3.2 *Test of Resistance to High Temperature*

5.3.2.1 When tested in accordance with **6.7**, no significant change, for example whitening, bubbles, or delamination, excepting surface cracks, shall form more than 15 mm from an uncut edge or 25 mm from a cut edge of the test piece or sample or more than 10 mm away from any cracks which may occur during the test.

5.3.2.2 Test *Pieces*

Three test pieces shall be tested and each shall meet the requirements. The test pieces shall be as described in **6.7.2**.

5.3.3 *Test of Resistance to Humidity*

5.3.3.1 When tested in accordance with **6.9**, at the time specified in **6.9.1.4** or **6.9.1.5**, as appropriate, no significant change, for example, whitening, bubbles, or delamination, excepting surface cracks, shall be observed more than 10 mm from the uncut edges and more than 15 mm from the cut edges.

5.3.3.2 Additionally, for Plastic Glazing, the light transmittance does not fall to less than 95 percent of the pre-test value and additionally to no less than 70 percent for any window required for driver visibility.

5.3.3.3 *For Plastic Glazing*: After testing , the test pieces shall be stored for atleast 48 h at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5percent and then subjected to the 227 g ball drop test described under **6.3**.

5.3.3.2 *Test Pieces*

Three test pieces shall be tested and each shall meet the requirements. The test pieces shall be as described in **6.9.2**.

5.4 Requirements Applicable to Windscreens

5.4.1 *Optical Distortion Test*

When tested in accordance with **6.12** optical distortion shall not exceed the values given below for each zone or test area.

5.4.1.1 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.

Vehicle Category	*Zone or Test Area*	*Maximum Values of Optical Distortion*
M1and N (derived from a M1 where the windscreen and seating positions are identical)	A — extended according to **7.1.3.3.2**. Alternatively, Central Area as per **7.1.4**.	2' of arc
	B — reduced according to **7.1.3.3.4**. Alternatively, Outer Area as per **7.1.4**.	6' of arc
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**.	2' of arc
	Secondary area as defined in IS 16325 Alternatively, Outer Area as per **7.1.4**.	6' of arc
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**.Alternatively, Central Area as per **7.1.4**.	2' of arc

5.4.1.2 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.

5.4.1.3 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.

5.4.1.4 *Test pieces*

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

5.4.1.5 *Alternate test method*

Alternate test procedure of optical distortion test as **6.12.6** shall be also accepted.

5.4.2 *Secondary image separation test*

When tested in accordance with **6.13** separation of the primary and secondary image shall not exceed the values given below for each zone or test area.

Vehicle Category	*Zone or Test Area*	*Maximum Values of the Separation of the Primary and Secondary Images*
M1 and N (derived from a M1 where the windscreen and seating positions are identical)	A — extended according to **7.1.3.3.2**. Alternatively, Central Area as per **7.1.4**.	15' of arc
	B — reduced according to **7.1.3.3.4**. Alternatively, Outer Area as per **7.1.4**.	25' of arc
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**.	15' of arc
	Secondary area as defined in IS 16325. Alternatively, Outer Area as per **7.1.4**.	25' of arc
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**. Alternatively, Central Area as per **7.1.4**.	15' of arc

5.4.2.1 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.

5.4.2.2 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.

5.4.2.3 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.

5.4.2.4 *Test pieces*

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

5.4.2.5 *Alternate test method*

Alternate test procedure of Secondary Image Separation Test as per **6.13.5** shall be also accepted.

5.4.3 *Head-form Test on Windscreens*

When tested in accordance with **6.5**, at the drop height of 1.5 m $^{+0}_{-5}$ mm (for tests on actual wind screen as per **6.5.3**) or 4.0 m $^{+15}_{-0}$ mm (for tests on flat test pieces as per **6.5.2**), the windscreen shall meet the following requirements.

NOTES

1 This test is not applicable for vehicle of 'L' category.

2 Test conducted as per **6.5.2** shall also be acceptable for the compliance to **5.4.3**.

5.4.3.1 The windscreen shall break displaying numerous circular cracks centred approximately on the point of impact, the cracks nearest to the point of impact being not more than 80 mm from it.

5.4.3.2 The layers of glass shall remain adhering to the interlayer. One or more partial separations from the interlayer with a distance of less than 4 mm in breadth, on either side of the crack, are allowed outside a circle of 60 mm diameter centred on the point of impact.

5.4.3.3 *On the impact side*

5.4.3.3.1 The interlayer shall not be laid bare over an area of more than 20 cm^2.

5.4.3.3.2 A tear in the interlayer up to a length of 35 mm is allowed.

5.4.3.4 *Test pieces*

5.4.3.4.1 Eight windscreens shall be tested and at least seven shall meet the requirements, or,

5.4.3.4.2 Eight flat test pieces specified at **6.5.5.1** shall be tested and at least seven shall meet the requirements.

5.4.4 *2.260 g Ball Test*

When tested in accordance with **6.4**, at the drop height of 4 m mm, the ball shall not pass

through the glazing within 5 s after the moment of impact.

5.4.4.1 *Test pieces*

Twelve test pieces shall be tested and at least eleven shall meet the requirements. The test pieces shall be as described in **6.4.4**.

5.4.5 *227 g Ball Test*

When tested in accordance with **6.3**, at the temperature and drop height specified in **6.3.3.4**, the test piece shall meet the following requirements:

5.4.5.1 The ball does not pass through the test piece.

5.4.5.2 The test piece does not break into separate pieces.

5.4.5.3 Tears in the interlayer are allowed provided that the ball does not pass through the test piece.

5.4.5.4 If the interlayer is not torn, the mass of fragments detached from the side of the glass opposite to the point of impact shall not exceed the applicable values specified in **6.3.3.4**.

5.4.5.5 *Test pieces*

Ten test pieces shall be tested at each of the specified temperatures and at least eight of each ten shall meet the requirements. The test pieces shall be as described in **6.3.4**.

5.5 Requirements Applicable to Panes

5.5.1 *Requirements Applicable Only to Uniformly Toughened Glass Panes*

5.5.1.1 *Fragmentation test*

When tested in accordance with **6.2**, at the points specified in **6.2.2.2**, uniformly toughened glass shall fragment as follows:

5.5.1.1.1 The number of fragments in any 5 cm × 5 cm square shall not be less than 40.

5.5.1.1.2 For the purposes of this requirement, a fragment extending across at least one side of a square shall count as half a fragment.

5.5.1.1.3 When a fragment extends beyond the excluded area only the part of the fragment falling outside of the area shall be assessed.

5.5.1.1.4 Fragments of an area exceeding 3 cm^2 shall not be allowed except in the parts defined in **6.2.2.3**.

5.5.1.1.5 No fragment longer than 100 mm in length shall be allowed except in the areas defined in **6.2.2.3**. Provided that:

5.5.1.1.5.1 Fragment ends do not converge to a point.

5.5.1.1.5.2 If they extend to the edge of the pane they do not form an angle of more than 45° to it.

5.5.1.1.6 *Test pieces*

Four panes shall be tested from each point of impact and at least three shall meet the requirements.

5.5.1.2 *227 g Ball Test*

When tested in accordance with **6.3**, at the drop height specified in **6.3.3.2**, the test piece shall not break.

5.5.1.2.1 *Test pieces*

Six test pieces shall be tested and at least Five shall meet the requirements. The test pieces shall be as described in **6.3.4**.

5.5.2 *Requirements Applicable only to Laminated-Glass and Glass-Plastic Panes*

5.5.2.1 *227 g ball test*

When tested in accordance with **6.3**, at the drop height specified in **6.3.3.3**, the test piece shall meet the following requirements:

5.5.2.1.1 The ball shall not pass through the test piece.

$^{+25}_{-0}$**5.5.2.1.2** The laminate shall not break into separate pieces.

5.5.2.1.3 At the point immediately opposite the point if impact, small fragments of glass may leave the specimen, but the small area thus affected shall expose less than 645 mm^2 of reinforcing or strengthening material, the surface of which shall always be well covered with tiny particles of tightly adhering glass. Total separation of glass from the reinforcing or strengthening material shall not exceed 1 935 mm^2 on either side. Spalling of the outer glass surface opposite the point of impact and adjacent to the area of impact is not to be considered a failure.

5.5.2.1.4 *Test pieces*

Eight test pieces shall be tested and at least Six shall meet the requirements. The test pieces shall be as described in **6.3.4**.

5.5.3 *Requirements Applicable only to Double-Glazed Units*

5.5.3.1 *Individual components*

Each component pane forming the double-glazed unit shall be separately subjected to the requirements set out in **6** as appropriate for that type of glazing.

5.5.3.2 *Head-form Test*

When tested in accordance with **6.5** at a drop height of 1.50 m +0/-5 mm, the test pieces shall meet following requirements:

5.5.3.2.1 A double-glazed unit consisting of two uniformly toughened-glass panes shall break.

5.5.3.2.2 A double-glazed unit consisting of laminated-glass panes and/or glass-plastics panes shall meet the following requirements:

5.5.3.2.2.1 The two components of the test piece yield and break, displaying numerous circular cracks centred approximately on the point of impact.

5.5.3.2.2.2 Tears in the interlayer(s) are allowed provided that the head-form does not pass through the test piece.

5.5.3.2.2.3 No fragment larger than 10 cm^2 becomes detached from the interlayer.

5.5.3.2.3 A double-glazed unit consisting of a uniformly toughened-glass pane and of a laminated-glass pane or glass-plastics pane shall meet the following requirements:

a) The uniformly toughened glass pane breaks;
b) The laminated-glass pane or glass-plastics pane:
   1) Yields and breaks, displaying numerous circular cracks centred approximately on the point of impact;
   2) Tears in the interlayer(s) are allowed provided that the head-form does not pass through the test piece;
   3) No fragment larger than 10 cm^2 becomes detached from the interlayer.

5.5.3.2.4 *Test pieces*

Twelve test pieces shall be tested and at least Eleven shall meet the requirements.The test pieces shall be as described in **6.5.5.1**. In the case of an asymmetrical double-glazed unit, six tests shall be carried out on one side and six tests on the other side.

5.6 Requirements Specific to Rigid Plastic Glazing

5.6.1 *Head-form Test*

5.6.1.1 The method used shall be that described in **6.16**

5.6.1.2 Six flat test pieces (1 170 × 570 +0/-2 mm) or six complete parts shall be subjected to testing.

5.6.1.3 For panes like partitions and separating windows which have impact probability (Classification VIII/A) the drop height shall be 3 m. The HIC value has to be measured.

5.6.1.4 For panes like side windows and back windows which have reduced impact possibilities (Classification VIII/B) the drop height shall be 1.5m. The HIC value is also to be measured.

5.6.1.5 For panes which do not have contact possibilities as well as for small windows in vehicles and for all windows in trailers (Classification VIII/C) there will be no headform testing. A small window is a window into which a 150 mm diameter circle cannot be scribed.

5.6.1.6 The test shall be deemed to have given a satisfactory result if the following conditions are fulfilled.

5.6.1.7 The test piece or sample is not penetrated nor shall it break into fully separate large pieces.

5.6.1.8 The HIC value is less than 1 000.

5.6.2 *Mechanical Strength Test — 227g Ball*

5.6.2.1 The method used shall be that described in **6.3**

5.6.2.2 Ten Flat Square pieces (300 +10/-0 mm) or ten substantially flat finished parts shall be subjected to testing.

5.6.2.3 The height of drop for the various thickness values is given in below:

Sheet Thickness, mm	*Height of Drop,* m
≤ 3	2
4	3
5	4
≥ 6	5

For intermediate values of test piece thickness in the interval between 3 mm and 6 mm the height of drop must be interpolated.

5.6.2.4 *Interpretation of Results*

The ball test shall be considered to have given a satisfactory result if the following conditions are met:

a) The ball does not penetrate the test piece.
b) The test piece does not break into separate pieces.

As a result of the impact, cracks and fissures in the sheet are however permissible.

5.6.2.5 *227g Ball Test at –18° ± 2°C*

5.6.2.5.1 To minimize the temperature change of the test piece, the test shall be performed within 30 s of the removal of the test piece from the conditioning appliance.

5.6.2.5.2 The test method shall be as per **6.3**, except that the test temperature is –18° ± 2°C.

5.6.2.5.3 Interpretation of results to be as per **5.6.2.4.**

5.6.3 *Flexibility and Fold Test*

5.6.3.1 One flat test piece measuring 300 mm × 25 mm shall be subjected to testing.

5.6.3.2 The method used shall be that mentioned in **6.17**.

5.6.3.3 *Interpretation of results*

For a test piece or sample to be considered rigid, the vertical deflection of the test piece shall be less than or equal to 50 mm after 60 s.

5.6.4 *Weathering*

5.6.4.1 The test method shall be that mentioned in **6.18**. The total ultraviolet radiant exposure with the long arc xenon lamp shall be 500 $MJ/m^{2.}$. During irradiation, the test pieces shall be exposed to water spray in continuous cycles. During a cycle of 120 min, the test pieces are exposed to light without water spray for 102 min, and to light with water spray for 18 min.

5.6.4.2 Other methods giving equivalent results shall be allowed.

5.6.4.3 *Number of test pieces*

Three flat pieces 130 mm × 40 mm cut from a flat sheet sample shall be subjected to testing.

5.6.4.4 *Interpretation of results*

The resistance to the simulated weathering shall be considered to have given a satisfactory result if:

a) the light transmittance measured in accordance with **6.1** does not fall below 95 percent of the pre-weathering value. Additionally, for windows which are required for driver visibility, the value shall not fall below 70 percent.
b) no bubbles or other visible decompositions, discolourations, milkiness or crazing shall occur during weathering.
c) a set of test pieces or samples submitted for approval shall be considered satisfactory from the point of view of the resistance to simulated weathering if one of the following conditions is met.
d) all test pieces have given a satisfactory result.
e) one test piece having given an unsatisfactory result, a further series of tests carried out on a new set of test pieces or samples gives satisfactory results.

5.6.5 *Cross-cut*

5.6.5.1 The method used shall be that mentioned in **6.19.**

5.6.5.2 The cross-cut test shall be carried out on one of the test pieces from **5.6.4.**

5.6.5.3 *Interpretation of Results*

The cross-cut test shall be considered to have given a satisfactory result if:

a) the cross-cut value Gt1 is met (*see* **6.19.4**).
b) the test piece shall be considered satisfactory from the point of view of approval if one of the following conditions is met.
    1) The test has given satisfactory results.
    2) The test having given an unsatisfactory result, a further test carried out on another remaining test piece from test **5.6.4** gives satisfactory results.

5.7 Requirements Specific to Flexible Plastic Glazing

5.7.1 *227 g Ball Test at 20 ± 5°C*

Ten flat square pieces (300 +10/-0 mm) shall be subjected to testing. The test method used shall be that prescribed in **6.3**. The height of drop shall be 2 m for all thicknesses.

5.7.1.1 *Interpretation of results*

The ball test shall be considered to have given a satisfactory result if the ball does not penetrate the test piece.

5.7.2 *227g Ball Test at –18° ± 2°C*

To minimize the temperature change of the test piece, the test shall be performed within 30 s of the removal of the test piece from the conditioning appliance. The test method shall be as per **6.3**, except that the test temperature is –18° ± 2°C.

5.7.2.1 *Interpretation of results*

The ball test shall be considered to have given a satisfactory result if the ball does not penetrate the test piece.

5.7.3 *Flexibility Test and Fold Test*

One flat test piece measuring 300 mm × 25 mm shall be subjected to testing. The method used shall be that mentioned in **6.17**.

5.7.3.1 *Interpretation of results*

For a test piece or sample to be considered flexible, the vertical deflection of the test piece shall be more than 50 mm after 60 s. Ten seconds after a 180° folding, the material must not show any fracture or damage at the point of bending.

6 TEST CONDITIONS AND PROCEDURES

6.1 Test Conditions

Unless specified otherwise, the test conditions shall be as follows:

a) Temperature: 20 ± 5°C;
b) Pressure: 860 to 1 060 mbar; and
c) Relative humidity: 60 ± 20 percent.

6.2 Fragmentation Test

6.2.1 *Apparatus*

To obtain fragmentation, a spring-loaded centre punch or a hammer of 75 g ± 5 g, each with a point having a radius of curvature of 0.2 ± 0.05 mm, shall be used.

6.2.2 *Procedure*

6.2.2.1 The test piece to be tested shall not be rigidly secured; it may however be fastened on an identical test piece by means of adhesive tape applied all round the edge.

6.2.2.2 One test shall be carried out at each of the prescribed point of impact.

6.2.2.3 Fragmentation shall not be checked in a strip 2 cm wide round the edge of the samples, this strip representing the frame of the glass, nor within a radius of 7.5 cm from the point of impact.

6.2.2.4 Examination of the fragmentation pattern shall start within 10 seconds and shall be completed within 3 min after the impact.

6.2.3 Points of impact for uniformly toughened glass panes are as follows, and represented in **7.2** (*see* Fig. 31 to Fig. 33).

a) Point 1 in the Geometric Centre of the Glass.
b) Point 2 for curved glass panes only; this point shall be selected on the largest median in that part of the pane where the radius of curvature "*r*" of the glazing is less than 200 mm.

6.2.3.1 *Test pieces*

Four panes for each point of impact.

6.3 227 g Ball Test

6.3.1 *Apparatus*

6.3.1.1 Solid, smooth, hardened-steel ball with a mass of 227 g ± 2 g and a diameter of approximately 38 mm.

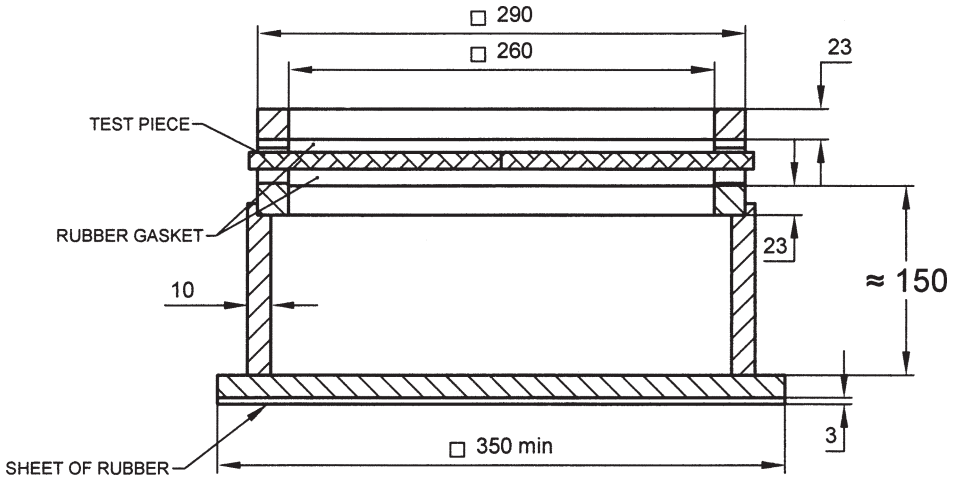
6.3.1.2 Means for dropping the ball freely from the height given in **6.3.3**, or a means for giving the ball a velocity equivalent to that obtained by the free fall. When a device to project the ball is used, the tolerance on velocity shall be ± 1 per cent of the velocity equivalent to that obtained by the free fall.

6.3.1.3 Supporting fixture, such as that shown in Fig. 1, composed of steel frames, with machined borders 15 mm wide, fitting one over the other and faced with rubber gaskets 3 mm thick and 15 mm wide and of hardness 50 ± 10 International Rubber Hardness Degree (IRHD).

The lower frame rests on a steel box 150 mm high. The test piece is held in place by the upper frame, the mass of which is 3 kg. The supporting frame is welded onto a sheet of steel 12 mm thick resting on the floor with an interposed sheet of rubber 3 mm thick and of hardness 50 ± 10 IRHD.

6.3.2 *Procedure*

6.3.2.1 Condition the test piece at the temperature



All dimensions in millimetres.

FIG. 1 SUPPORT FOR BALL TESTS

specified in **6.1.1** for at least 4 h immediately preceding the test. In the case of laminated-glass and glass plastic windscreens the temperatures will be as specified in **6.3.3.4**.

6.3.2.2 Place the test piece in the fixture described in **6.3.1.3**. The plane of the test piece shall be perpendicular, within 3°, to the incident direction of the ball. In the case of flexible plastic glazing, the test piece shall be clamped to the support.

6.3.2.3 The point of impact shall be within 25 mm of the geometric centre of the test piece for a drop height less than or equal to 6 m, and within 50 mm of the centre of the test piece for a drop height greater than 6 m.

6.3.2.4 The ball shall strike the outer face of the test piece.

NOTE — Glass / Plastic glazing manufacturer to provide marking of inner and outer surface on cut pieces.

6.3.2.5 The ball shall make only one impact.

6.3.3 *Drop Height*

6.3.3.1 The drop height shall be measured from the under-face of the ball to the upper face of the test piece.

6.3.3.2 For Uniformly Toughened Glass Panes, the drop height shall be 2.0 m +5/-0 mm.

6.3.3.3 For Laminated-Glass and Glass-Plastic Panes, the drop height shall be 9m +2/-0 mm.

6.3.3.4 For laminated-glass and glass-plastic windscreens, the drop height and the mass of the detached fragments shall be as indicated in Table 2, where *e* equals the nominal thickness of the specimen being tested. A tolerance of +25/-0 mm is allowed in the height of fall.

For all Glazing excluding Plastic glazing, ten test pieces shall be tested at a temperature of +40 ± 2°C and ten at a temperature of –20 ± 2°C.

6.3.3.5 For Plastic glazing, the height of drop for the various thickness values of the outer compartment of the window is given below.

Outer Sheet Thickness, mm	*Height of Drop,* m
≤ 3	2
4	3
5	4
≥ 6	5

For intermediate values of test-piece thickness in the interval between 3 mm and 6 mm the height of drop must be interpolated.

For Plastic Glazing, the 227g ball test at –18 ± 2°C is to be done using the procedure described above.

6.3.4 *Test Pieces*

6.3.4.1 The test pieces shall be flat samples measuring 300 mm × 300 mm, specially made or cut from the flattest part of a windscreen or pane.

6.3.4.2 Finished products may alternatively be used as test pieces which shall be supported over the apparatus described in **6.3.1**.

6.3.4.3 If the test pieces are curved, care should be taken to ensure adequate contact with the support.

6.4 2.260 g Ball Test

6.4.1 *Apparatus*

6.4.1.1 Solid hardened-steel ball with a mass of 2 260 g ± 20 g.

6.4.1.2 Means for dropping the ball freely from the height specified in **6.4.3** or means for giving the ball a velocity equivalent to that obtained by the free fall.

When a device to project the ball is used, the tolerance on velocity shall be ± 1 per cent of the velocity equivalent to that obtained by the free fall.

6.4.1.3 The supporting fixture shall be as shown in Fig. 1 and identical with that described in **6.3.1.3**.

6.4.2 *Procedure*

6.4.2.1 Condition the test piece at the temperature specified in **6.1.1** for at least 4 h immediately preceding the test.

Table 2 Drop Height and the Mass of Detached Fragments
(*Clause* 6.3.3.4)

Nominal Thickness of Test Pieces	**+40 ± 2° C**		**–20 ± 2° C**	
	Height of Fall	Maximum Permitted Mass of the Fragments	Height of Fall	Maximum Permitted Mass of the Fragments
mm	m	g	m	g
$e \leq 4.5$	9	12	8.5	12
$4.5 < e \leq 5.5$	9	15	8.5	15
$5.5 < e \leq 6.5$ $e > 6.5$	9	20	8.5	20
	9	25	8.5	25

6.4.2.2 Place the test piece in the supporting fixture. The plane of the test piece shall be perpendicular within 3°, to the incident direction of the ball.

6.4.2.3 In the case of glass-plastics glazing the test piece shall be clamped to the support. All other glazing shall not be clamped.

6.4.2.4 The point of impact shall be within 25 mm of the geometric centre of the test piece.

6.4.2.5 The ball shall strike the inner face of the test piece.

6.4.2.6 The ball shall make only one impact.

6.4.3 *Drop Height*

6.4.3.1 The drop height shall be measured from the under face of the ball to the upper face of the test piece.

6.4.3.2 The drop height shall be 4.0 m +5/0 mm.

6.4.4 *Test Pieces*

6.4.4.1 The test pieces shall be flat samples measuring 300 mm × 300 mm, specially made or cut from the flattest part of a windscreen.

6.4.4.2 Finished products may alternatively be used as test pieces which shall be supported over the apparatus described in **6.3.1**.

6.4.4.3 If the test pieces are curved, care should be taken to ensure adequate contact with the support.

6.5 Head-form Test

6.5.1 *Apparatus*

6.5.1.1 *Head-form*

6.5.1.1.1 Spherical or semi-spherical head-form made of laminated hardwood covered with replaceable felt and with or without a crossbeam made of wood. There is a neck shaped intermediate piece between the spherical part and the crossbeam and a mounting rod on the other side of the crossbeam.

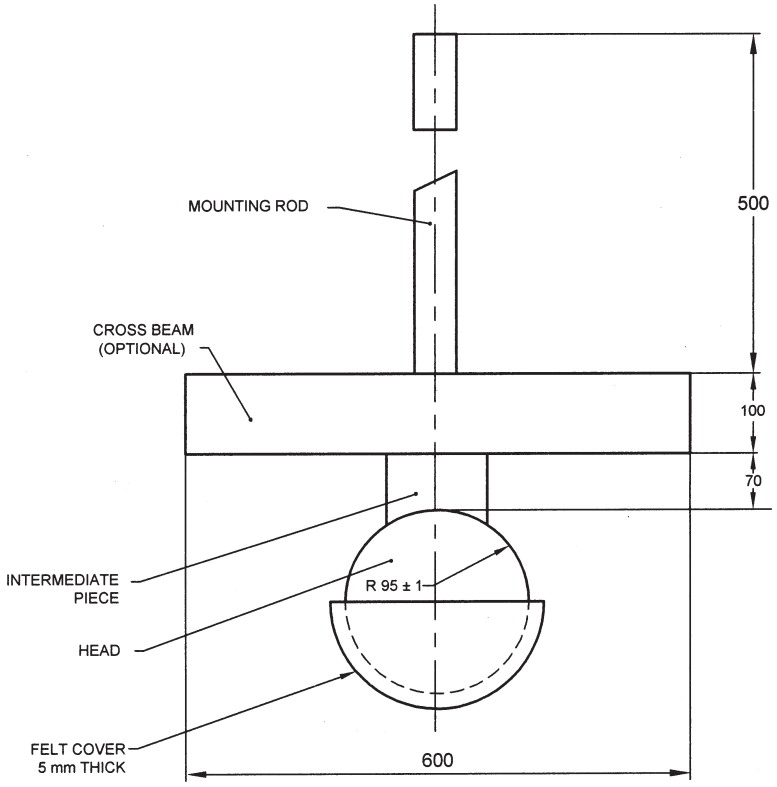
6.5.1.1.2 The dimensions shall be in accordance with Fig. 2.

6.5.1.1.3 The total mass of the head-form shall be 10 ± 0.2 kg.

6.5.1.2 Means for dropping the head-form freely from a height to be specified, or means for giving the head-form a velocity equivalent to that obtained by the free fall. When a device to project the head-form is used, the tolerance on velocity shall be ± 1percent of the velocity equivalent to that obtained by the free fall.

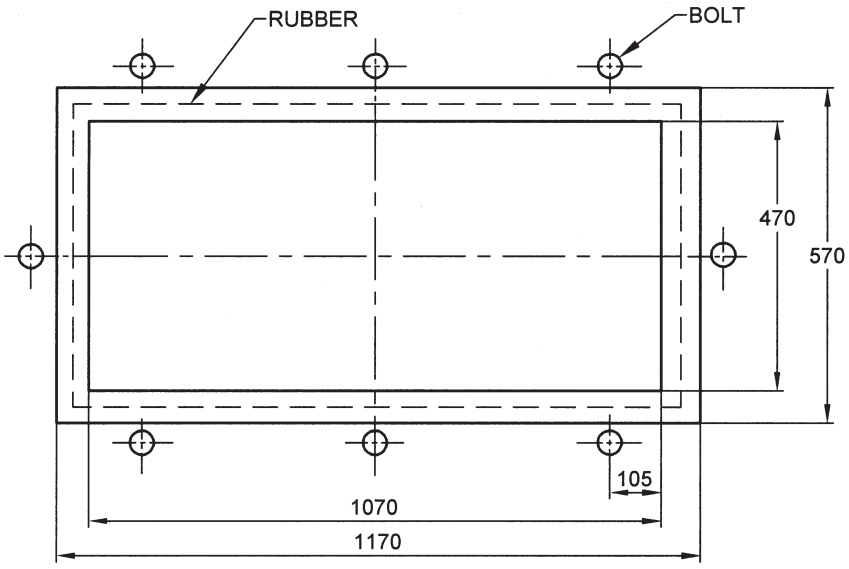
6.5.1.3 Supporting fixture shall be as shown in Fig. 3, for testing Flat Test Pieces. The fixture is composed of two steel frames, with machined borders 50 mm wide, fitting one over the other and faced with rubber gaskets 3 mm thick and 15 ± 1 mm wide and of hardness 70 ± 10 IRHD.

The upper frame is held pressed against the lower frame by at least eight bolts. The torque on the bolts shall



All dimensions in millimetres.

FIG. 2 HEAD-FORM



NOTE — The minimum recommended torque for M20 bolt size is 30 N-m.

All dimensions in millimetres.

FIG. 3 HEAD-FORM TEST SUPPORT FOR FLAT SAMPLES

ensure that the movement of the test piece during the test will not exceed 2 mm.

6.5.1.4 *Supporting fixture for windscreens*

The support shall consist of a rigid piece corresponding to the shape of the windscreen so that the head-form strikes the inner face of the windscreen. It has an interposed strip of rubber of hardness 70 ± 10 IRHD, thickness 3 mm and width 15 mm. The support shall rest on a rigid stand with an interposed sheet of rubber of hardness 70 ± 10 IRHD and thickness 3 mm.

6.5.2 *Procedure for Tests on Flat Test Pieces*

6.5.2.1 Condition the test piece at the temperature specified in **6.1.1** for at least 4 h immediately preceding the test.

6.5.2.2 Fix the test piece in the supporting frame described in **6.5.1.3**.

6.5.2.3 The plane of the test piece shall be perpendicular within 3°, to the incident direction of the head-form.

6.5.2.4 The head-form shall strike the test piece within 40 mm of its geometric centre on its inner face.

6.5.2.5 The head-form shall make only one impact.

6.5.2.6 The impact surface of the felt cover shall be replaced after each successive 12 tests.

6.5.3 *Procedure for Tests on Windscreens*

6.5.3.1 Condition the test piece at the temperature specified in **6.1.1** for at least 4 h immediately preceding the test.

6.5.3.2 Place the windscreen freely on a supporting fixture as described in **6.5.1.4**.

6.5.3.3 The plane of the windscreen shall be perpendicular within 3°, to the incident direction of the head-form.

$^{+00}_{-2}$

6.5.3.4 The head-form shall strike the windscreen within 40 mm of its geometric centre on its inner face.

6.5.3.5 The head-form shall make only one impact.

6.5.3.6 The impact surface of the felt cover shall be replaced after each successive 12 tests.

6.5.4 *Drop Height*

6.5.4.1 The drop height shall be measured from the under-face of the head-form to the upper face of the test piece.

6.5.4.2 It shall be 1.5 m mm for tests conducted on windscreens and on flat samples for double glazed units.

6.5.5 *Test Pieces*

6.5.5.1 The test pieces according to **6.5.2** shall be flat samples measuring 1 100 mm × 500 mm mm.

6.5.5.2 The test pieces according to **6.5.3** shall be windscreens.

6.6 Test of Resistance to Abrasion

6.6.1 *Apparatus*

6.6.1.1 Abrading instrument as shown in Fig. 4 and consisting of:

a) a horizontal turntable, with centre clamp, which revolves counter-clockwise at 65 to 75 rev/min.

b) two weighted parallel arms each carrying a special abrasive wheel freely rotating on a ball-bearing horizontal spindle; each wheel rests on the test specimen under the pressure exerted by a mass of 500 g.

c) the turntable of the abrading instrument shall rotate regularly; substantially in one plane (the deviation from this plane shall not be greater than ± 0.05 mm at a distance of 1.6 mm from the turntable periphery).

d) the wheels shall be mounted in such a way that when they are in contact with the rotating test piece they rotate in opposite directions so as to exert, twice during each rotation of the test piece, a compressive and abrasive action along curved lines over an annular area of about 30 cm^2.

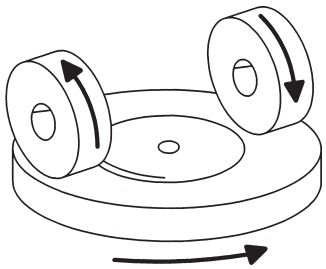


FIG. 4 DIAGRAM OF ABRADING INSTRUMENT

6.6.1.2 Abrasive wheels , each 45 mm to 50 mm in diameter and 12.5 mm thick, composed of a special finely-screened abrasive embedded in a medium hard rubber.

6.6.1.2.1 The wheels shall have a hardness of 72 ± 5 IRHD, as measured at four points equally spaced on the centerline of the abrading surface, the pressure being applied vertically along a diameter of the wheel and the readings being taken 10 s after full application of the pressure.

6.6.1.2.2 The abrasive wheels shall be prepared for use by very slow rotation against a sheet of flat glass to ensure that their surface is completely even.

6.6.1.3 Light source consisting of an incandescent lamp with its filament contained within a parallele piped measuring 1.5 mm × 1.5 mm × 3 mm. The voltage at the lamp filament shall be such that the colour temperature is 2 856 ± 50 K. This voltage shall be stabilized within ± 1/1 000.

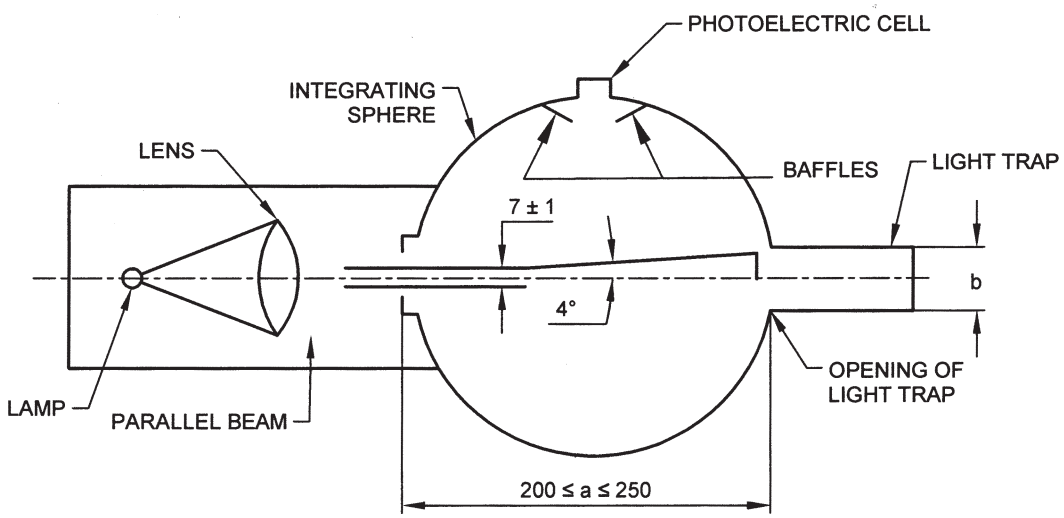
6.6.1.4 Optical system consisting of a lens with a focal length (*f*) of at least 500 mm and corrected for chromatic aberrations.

6.6.1.4.1 The full aperture of the lens shall not exceed *f*/20.

6.6.1.4.2 The distance between the lens and the light source shall be adjusted in order to obtain a light beam which is substantially parallel.

6.6.1.4.3 A diaphragm shall be inserted to limit the diameter of the light beam to 7 ± 1 mm. This diaphragm shall be situated at a distance of 100 ± 50 mm from the lens on the side remote from the light source.

6.6.1.5 Equipment for measuring scattered light (*see* Fig. 5), consisting of a photoelectric cell with an integrating sphere 200 to 250 mm in diameter. The sphere shall be equipped with entrance and exit ports for the light. The entrance port shall be circular and



All dimensions in millimetres.

FIG. 5 HAZEMETER

have a diameter at least twice that of the light beam. The exit port of the sphere shall be provided with either a light trap or a reflectance standard, according to the procedure described in **6.6.2.6**. The light trap shall absorb all the light when no test piece is inserted in the light beam.

6.6.1.5.1 The axis of the light beam shall pass through the centre of the entrance and exit ports. The diameter *b* of the light-exit port shall be equal to $2a \tan 4°$, where *a* is the diameter of the sphere. The photoelectric cell shall be mounted in such a way that the light coming directly from the entrance port or from the reflectance standard does not reach the cell.

6.6.1.5.2 The surfaces of the interior of the integrating sphere and the reflectance standard shall be of substantially equal reflectance and shall be matte and non-selective.

6.6.1.5.3 The output of the photoelectric cell shall be linear within ± 2 per cent over the range of luminous intensities used. The design of the instrument shall be such that there is no galvanometer deflection when the sphere is dark.

6.6.1.5.4 The whole apparatus shall be checked at regular intervals by means of calibration standards of defined haze.

6.6.2 *Procedure*

6.6.2.1 The abrasion test shall be carried out on that surface of the test piece which represents the outer side of the pane and also on the inner side if of plastics material.

6.6.2.2 Immediately before and after the abrasion, clean the test pieces in the following manner:

a) Wipe with a linen cloth under clean running water;
b) Rinse with distilled or demineralised water;
c) Blow dry with oxygen or nitrogen; and
d) Remove possible traces of water by dabbing softly with a damp linen cloth. If necessary, dry by pressing lightly between two linen cloths.

Any treatment with ultrasonic equipment is prohibited.

6.6.2.3 After cleaning, the test pieces shall be handled only by their edges and shall be stored to prevent damage to, or contamination of, their surfaces.

6.6.2.4 Recondition the test pieces as specified in **6.1** for a minimum time of 48 h.

6.6.2.5 Immediately place the test piece against the entrance port of the integrating sphere. The angle between the normal (perpendicular) to the surface of the test piece and the axis of the light beam shall not exceed 8°.

6.6.2.6 Take four readings as indicated below:

Reading	*With Test Piece*	*With Light Trap*	*With Reflectance Standard*	*Quantity Represented*
T_1	No	No	Yes	Incident light
T_2	Yes	No	Yes	Total light transmitted by instrument
T_3	No	Yes	No	Light scattered by instrument
T_4	Yes	Yes	No	Light scattered by instrument and test piece

6.6.2.7 Repeat readings for T_1, T_2, T_3 and T_4 with other specified positions of the test piece to determine uniformity.

6.6.2.8 Calculate the total transmittance

$$T_t = T_2 / T_1$$

6.6.2.9 Calculate the diffuse transmittance T_d as follows:

$$T_d = \frac{T_4 - T_3 (T_2 / T_1)}{T_1 - T_3}$$

6.6.2.10 Calculate the percentage haze, or light, or both, scattered, as follows:

6.6.2.11 Haze, or light or both, Scattered

$$= \frac{T_d}{T_t} \times 100 \text{ percent}$$

6.6.2.12 Measure the initial haze of the test piece at a minimum of four equally spaced points in the unabraded area in accordance with the formula above. Average the results for each test piece. In lieu of the four measurements, an average value may be obtained by rotating the piece uniformly at 3 rev/s or more.

6.6.2.13 For each type of safety glazing, carry out three tests with the same load. Use the haze as a measure of the subsurface abrasion, after the test piece has been subjected to the abrasion test.

6.6.2.14 Measure the light scattered by the abraded track at a minimum of four equally spaced points along the track in accordance with the formula above. Average the results for each test piece. In lieu of the four measurements, an average value may be obtained by rotating the piece uniformly at 3 rev/s or more.

6.6.3 *Test Pieces*

6.6.3.1 The test pieces shall be flat samples (square) measuring 100 mm × 100 mm having both surfaces substantially plane and parallel and having a fixing hole $6.4^{+0.2}_{-0}$ mm in diameter drilled in the center, if necessary.

6.7 Test of Resistance to High Temperature

6.7.1 *Procedure*

6.7.1.1 Heat to 100 °C.

6.7.1.2 Maintain this temperature for a period of two hours, and then allow the test pieces to cool to the temperature at 20°±5°C.

6.7.1.3 If the test piece has both external surfaces of inorganic material, the test may be carried out by immersing the test piece vertically in boiling water for the specified period of time, care being taken to avoid undue thermal shock.

6.7.2 *Test Pieces*

6.7.2.1 The test pieces shall be flat samples measuring 300 mm × 300 mm, which have been specially made or cut from the flattest part of three windscreens or three panes, as the case may be, one edge of which corresponds to the upper edge of the glazing.

6.7.2.2 *Alternate test method*

Alternate test procedure of boil test as per **5.3.4** of IS 2553 (Part 1) shall be also accepted.

6.8 Test of Resistance to Radiation

6.8.1 *Apparatus*

6.8.1.1 Radiation source consisting of a medium-pressure mercury-vapour arc lamp with a tubular quartz bulb of ozone-free type; the bulb axis shall be vertical. The nominal dimensions of the lamp shall be 360 mm in length by 9.5 mm in diameter. The arc length shall be 300 ± 4 mm. The lamp shall be operated at 750 ± 50 W.

Any other source of radiation which produces the same effect as the lamp specified above may be used. To check that the effects of another source are the same, a comparison shall be made by measuring the amount of energy emitted within a wavelength range of 300 to 450 nanometers, all other wavelengths being removed by the use of suitable filters.

6.8.1.2 Power-supply transformer and capacitor capable of supplying to the lamp specified in **6.8.1.1** a starting peak voltage of 1 100 V minimum and an operating voltage of 500 ± 50 V.

6.8.1.3 Device for mounting and rotating the test pieces at 1 to 5 rev/min about the centrally located radiation source in order to ensure even exposure.

6.8.2 *Procedure*

6.8.2.1 Check the regular light transmittance, determined according to **6.11**, of three test pieces before exposure. Protect a portion of each test piece from the radiation, and then place the test pieces in the test apparatus 230 mm from and parallel lengthwise to the lamp axis. Maintain the temperature of the test pieces at 45 ± 5 °C throughout the test.

6.8.2.2 That face of the test piece which would constitute the outer face of the glazing shall face the lamp.

6.8.2.3 The exposure time shall be 100 h. Each test piece shall be subjected to radiation such that the radiation on each point of the test piece produces on the interlayer the same effect as that which would be produced by solar radiation of 1 400 W/m^2 for 100 h.

6.8.2.4 After exposure, measure the regular light transmittance again in the exposed area of each test piece.

6.8.3 *Test Pieces*

6.8.3.1 The test pieces shall be flat samples measuring 76 mm × 300 mm or 300 mm × 300 mm, which have been specially made or cut from three windscreens or three panes, as the case may be, one edge of which corresponds to the upper edge of the glazing.

6.9 Test of Resistance to Humidity

6.9.1 *Procedure*

6.9.1.1 Keep samples in a vertical position for two weeks in a closed container in which the temperature is maintained at 50 ± 2 °C and the relative humidity at 95 ± 4 percent.

6.9.1.2 If several test pieces are tested at the same time, spacing shall be provided between them.

6.9.1.3 Precautions shall be taken to prevent condensate from the walls or ceiling of the test chamber from falling on the test pieces.

6.9.1.4 Before assessment, laminated-glass test pieces shall have been maintained for 2 h in the conditions specified in **6.1**.

6.9.1.5 Before assessment, test pieces of glass faced with plastic and of glass-plastics shall have been maintained for 48 h in the conditions specified in **6.1**.

6.9.2 *Test Pieces*

6.9.2.1 The test pieces shall be samples measuring 300 mm × 300 mm, which have been specially made or cut from three windscreens or three panes, as the case may be. One edge at least shall correspond to an edge of the glazing.

6.10 Test of Resistance to Temperature Changes

6.10.1 *Procedure*

6.10.1.1 Test pieces shall be placed in an enclosure at a temperature of – 40°C ± 5°C for a period of 6 h. They shall then be placed in the open air at a temperature of 23°C ± 2°C for 1 h or until temperature equilibrium has been reached by the test pieces.

NOTE — Components tested at –20 ± 5 °C shall be acceptable, as an alternate.

6.10.1.2 Test pieces shall then be placed in circulating air at a temperature of 72°C ± 2 °C for 3 h.

6.10.1.3 After being placed again in the open air at 23°C ± 2 °C and cooled to that temperature, the test pieces shall be examined.

6.10.2 *Test Pieces*

6.10.2.1 The test pieces shall be flat samples measuring 300 mm × 300 mm, which have been specially made or cut from three windscreens or panes, as the case may be.

6.11 Light Transmittance Test

6.11.1 *Apparatus*

6.11.1.1 Light source consisting of an incandescent lamp with its filament contained within a parallelepiped measuring 1.5 mm × 1.5 mm × 3 mm. The voltage at the lamp filament shall be such that the colour temperature is 2 856 ± 50 K. This voltage shall be stabilized within ± 1/1 000.

6.11.1.2 Optical system consisting of a lens with a focal length (*f*) of at least 500 mm.

6.11.1.2.1 The full aperture of the lens shall not exceed *f*/20.

6.11.1.2.2 The distance between the lens and the light source shall be adjusted in order to obtain a light beam which is parallel.

6.11.1.2.3 A diaphragm shall be inserted to limit the diameter of the light beam to 7 ± 1 mm. This diaphragm shall be situated at a distance of 100 ± 50 mm from the lens on the side remote from the light source. The point of measurement shall be taken at the centre of the light beam.

6.11.1.3 *Measuring Equipment*

6.11.1.3.1 The receiver shall have a relative spectral sensitivity in substantial agreement with the relative spectral luminous efficiency for the International Commission on Illumination standard photometric observer for photocopy vision. The sensitive surface of the receiver shall be covered with a diffusing medium and shall have at least twice the cross-section of the light beam emitted by the optical system. If an integrating sphere is used, the aperture of the sphere shall have a cross-sectional area at least twice that of the parallel portion of the beam.

6.11.1.3.2 The linearity of the receiver and the associated indicating instrument shall be within 2 percent of the effective part of the scale.

6.11.1.3.3 The receiver shall be centered on the axis of the light beam.

6.11.2 *Procedure*

6.11.2.1 The sensitivity of the measuring system shall be adjusted in such a way that the instrument indicating the response of the receiver indicates 100 divisions when the safety glazing material is not inserted in the light path. When no light is falling on the receiver, the instrument shall read zero.

6.11.2.2 Place the glazing at a distance from the receiver equal to five times the diameter of the receiver. Insert the glazing between the diaphragm and the receiver and adjust its orientation in such a way that the angle of incidence of the light beam is equal to 0 ± 5°. The regular light transmittance shall be measured on the glazing, and for every point measured the number of divisions, *n*, shown on the indicating instrument, shall be read. The regular transmittance *tr* is equal to *n*/100.

6.11.3 *Test Pieces*

6.11.3.1 Test pieces shall be either flat samples or finished products.

6.11.3.2 In the case of windscreens the test area shall be as defined in **7.1.3.2**.

6.12 Optical Distortion Test

6.12.1 *Apparatus*

The apparatus shall comprise the following items, arranged as shown in Fig. 6.

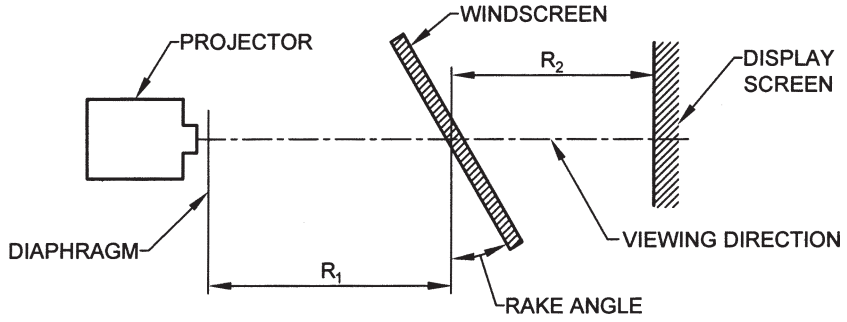
6.12.1.1 Projector with a high-intensity point light source.

6.12.1.1.1 The projector shall have the following characteristics:

a) Focal length at least 90 mm.
b) Aperture 1/2.5.
c) 150 W quartz halogen lamp *(if used without a filter)*.
d) 250 W quartz halogen lamp *(if a green filter is used)*.
e) The projector is shown schematically in Fig. 7. A diaphragm of 8 mm in diameter is positioned 10 mm from the front lens.

6.12.1.2 Slides (rasters) consisting, for example, of an array of bright circular shapes on a dark background (*see* Fig. 8). The slides shall be of sufficiently high quality and contrast to enable measurement to be carried out with an error of less than 5 per cent.

In the absence of the glazing to be examined, the dimensions of the circular shapes shall be such that when the circular shapes are projected they form an



R_1 = 4 m
R_2 = 2 to 4 m (4 m preferred)

FIG. 6 ARRANGEMENT OF THE APPARATUS FOR THE OPTICAL DISTORTION TEST

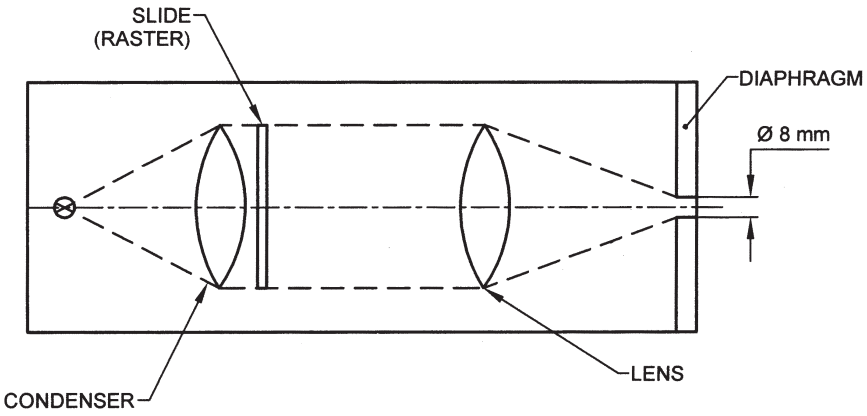


FIG. 7 OPTICAL ARRANGEMENT OF THE PROJECTOR

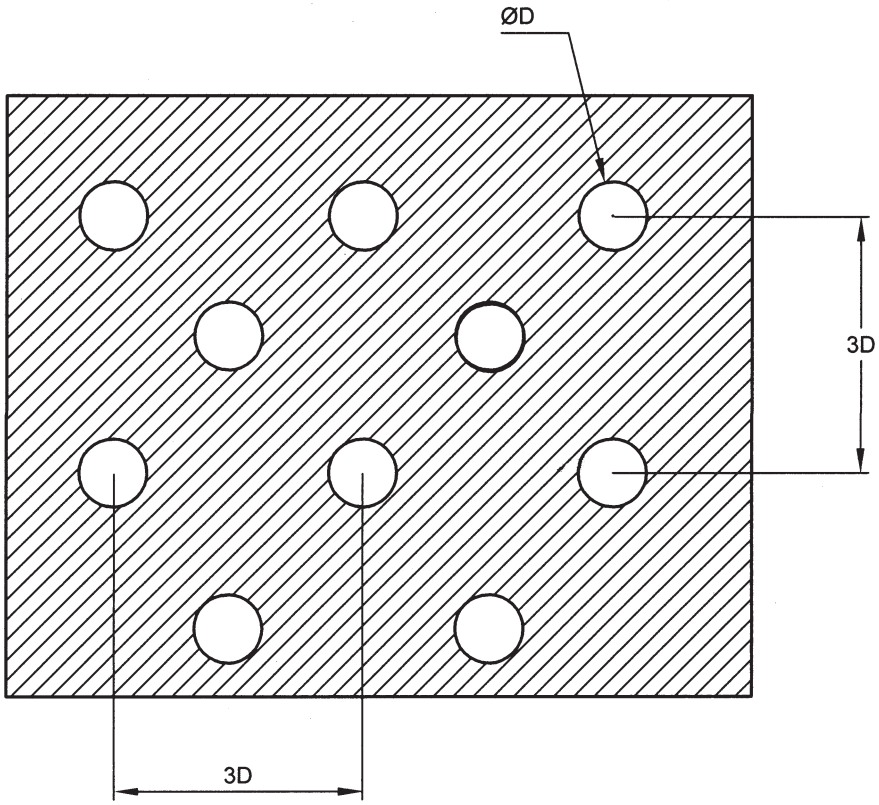


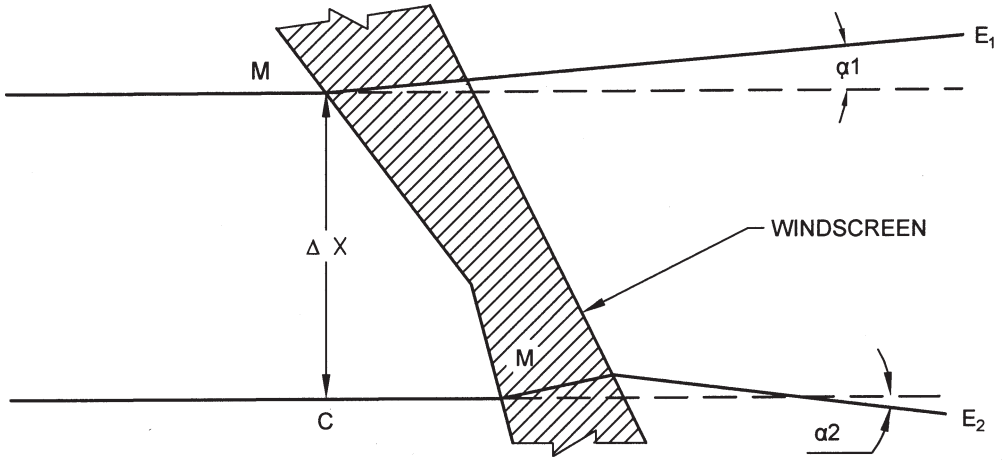
FIG. 8 ENLARGED SECTION OF THE SLIDE

array of circles of diameter:

$\frac{R_1 + R_2}{R_1} \times \Delta X$, where $\Delta X = 4$ mm (*see* Fig. 6 and Fig. 9)

6.12.1.3 Support stand, permitting vertical and horizontal scanning, rotation of the windscreen, and mounting of the windscreen at a full range of installation angles of inclination.

6.12.1.4 Checking template for measuring changes in dimensions. A suitable design is shown in Fig. 10.



NOTES

1 $\Delta\alpha = \alpha 1 - \alpha 2$, that is, optical distortion in the direction $M - M'$.

2 $\Delta X = MC$, that is, the distance between two straight lines parallel to the direction of vision and passing through the points M and M'.

FIG. 9 DIAGRAMMATIC REPRESENTATION OF OPTICAL DISTORTION

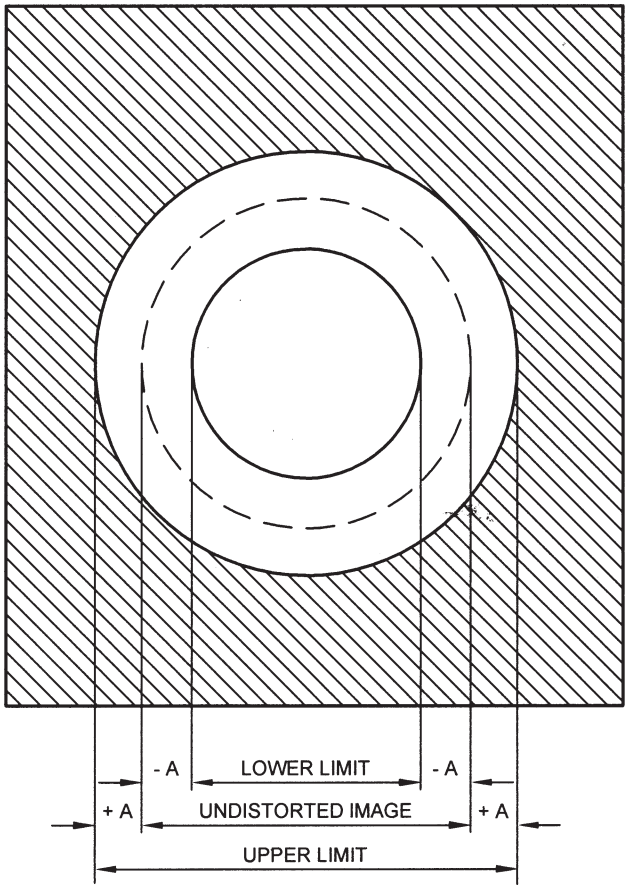


FIG. 10 DESIGN FOR A SUITABLE CHECKING TEMPLATE

6.12.2 *Procedure*

6.12.2.1 *General*

6.12.2.1.1 Mount the windscreen on the support stand at the designed angle of inclination.

6.12.2.1.2 Project the test image through the area being examined.

6.12.2.1.3 Rotate the windscreen or move it either horizontally or vertically in order to examine the whole of the specified area.

6.12.2.1.4 The distance Δx shall be 4 mm.

6.12.2.1.5 The projection axis in the horizontal plane shall be maintained approximately normal to the trace of the windscreen in that plane.

6.12.2.2 Calculate the value of A (*see* Fig. 10) from the limit value $\Delta\alpha_L$ for the change in deviation and the value of R_2, the distance from the windscreen to the display screen:

$$A = 0.145\ \Delta\alpha_L.\ R_2$$

The relationship between the change in diameter of the projected image Δd and the change in angular deviation $\Delta\alpha$ is given by

$$\Delta d = 0.29\Delta\alpha.\ R_2$$

where

Δd is in millimetres;
A is in millimetres;
$\Delta\alpha_L$ is in minutes of arc;
$\Delta\alpha$ is in minutes of arc; and
R_2 is in metres.

6.12.3 *Expression of Results*

Evaluate the optical distortion of the windscreen by

measuring Δd at any point of the surface and in all directions in order to find Δd max.

6.12.4 *Alternative Method*

A strioscopic technique is permitted as an alternative to the projection techniques, provided that the accuracy of the measurements given in **6.12.2.2** is maintained.

6.12.5 *Test Pieces*

6.12.5.1 The test pieces shall be windscreens.

6.12.6 *Alternate Test Method for Optical Distortion Test*

The test shall be carried out with the test piece at the designed angle of rake from the vertical in a dark room.

6.12.6.1 *Apparatus*

The apparatus shall consist of the following:

a) *Projector* — The projector shall have a light source of 150 to 250 W halogen lamp *and* an objective lens of focal length of 90 mm or more. A diaphragm to obtain sharp image may be attached as required (*see* Fig. 11).
b) *Slide* — The slide shall be capable of obtaining the image as shown in Fig.12.
c) *Screen* —The screen shall be white and flat.
d) *Supporting Fixture* —The supporting fixture shall be capable of mounting a specimen at the rake angle of a real car, and also of rotating and shifting in horizontal or vertical direction.
e) *Measuring instrument* —The measuring instrument shall be capable of measuring the distortion of the shape of the bright circle projected on the screen after passing through the specimen. The checking template as shown in Fig. 13 may be used.

where

D = the diameter of the circles projected on the screen, mm ($D = 8$ for $R_1 = R_2 = 4$ m),
R_1 = the distance from the projector to the specimen (*see* Fig.13), and
R_2 = the distance from the specimen to the screen (*see* Fig. 13).

Remark : A is determined by the following formula :

$$A\ (\text{mm}) = 0.145\ \Delta\alpha\ L \times R_2$$

where

$\Delta\alpha\ L$ = the maximum value of the change in deviation (minutes of arc), and
R_2 = 2 to 4 (m).

Arrange the projector, the supporting fixture and the screen as shown in Fig. 14. In the absence of the test piece, ascertain that the circular shaped part projected on the screen is D mm in diameter (for example in the case of $R_1 = R_2 = 4$ m, $D = 8$ mm is led by the formula described in Fig. 13). Place the test piece midway between the projector and the screen. Place the test piece on the supporting fixture at the designed rake angle. Rotating or moving the specimen horizontally and moving it vertically, while maintaining the distance at R, measure the maximum value of the change in diameter. Calculate the maximum value of the angular deviation by the following formula:

$$\Delta = \frac{\Delta d}{0.29 \times R_2}$$

where

Δ = the angular deviation (minutes of arc),
Δd = the change in diameter of the projected image (mm), and
R_2 = the distance from the specimen to the screen (m).

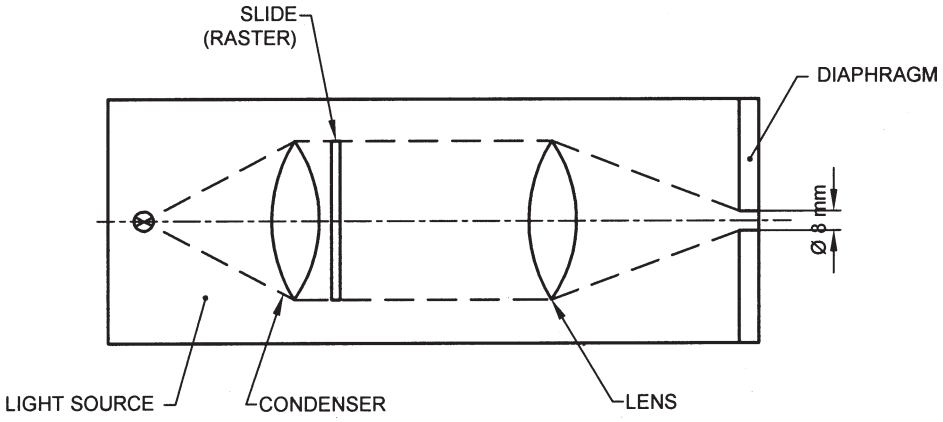
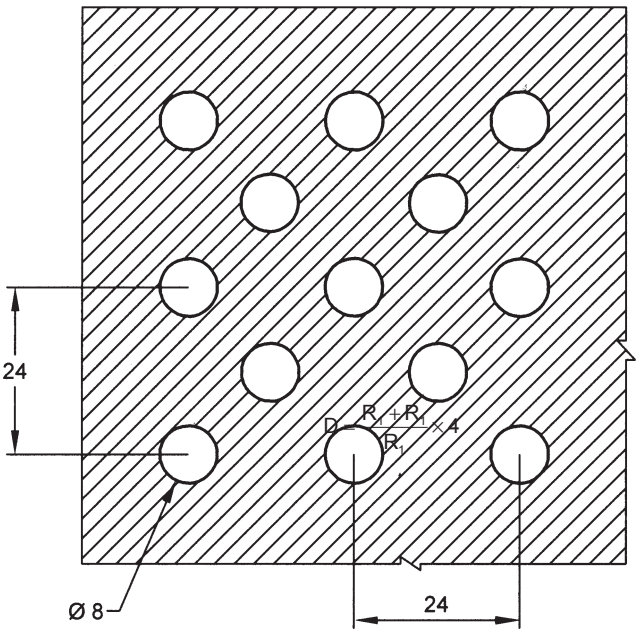


FIG. 11 PROJECTOR FOR OPTICAL DISTORTION TEST



All dimensions in millimetres.

FIG. 12 IMAGE PROJECTED ON THE SCREEN

6.12.6.2 *Interpretation of results*

The maximum angular deviation for windscreens made of sheet glass shall not be more than 8 minutes of arc for central area and 10 min of arc for outer area. For windscreens made of float glass the deviation shall not be more than 4 min of arc for central area and 6 min of arc for outer area.

6.13 Secondary Image Separation Test

6.13.1 *Target Test*

6.13.1.1 *Apparatus*

6.13.1.1.1 This method involves viewing an illuminated target through the windscreen. The target may be designed in such a way that it is possible to carry out test on a simple 'go-no go' basis.

6.13.1.1.2 The target shall be of one of the following types:

6.13.1.1.2.1 An illuminated 'ring' target whose outer diameter, *D*, subtends an angle of minutes of arc at a point situated at '*x*' metres [Fig. 15 (a)] or

6.13.1.1.2.2 An illuminated 'ring and spot' target whose dimensions are such that the distance, *D*, from a point on the edge of the spot to the nearest point on the

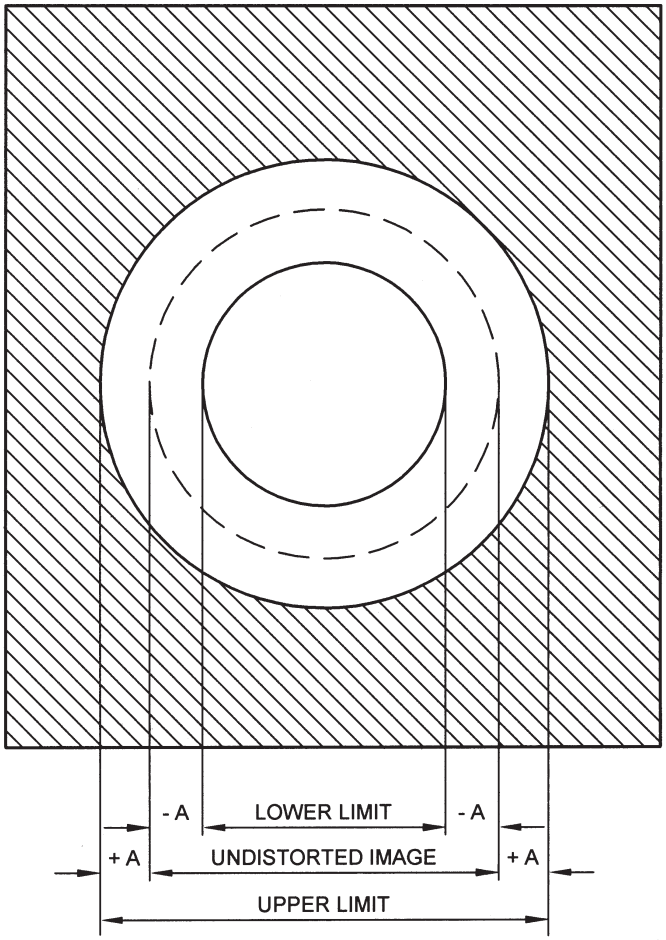
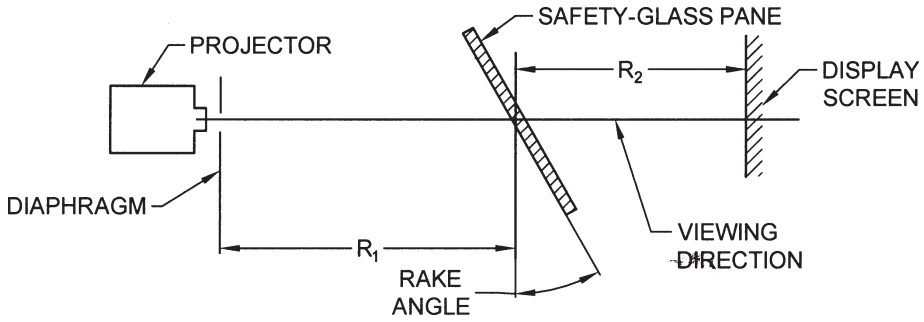


FIG. 13 CHECKING TEMPLATE



R_1 = 4 m and R_2 = 4 m

FIG. 14 ARRANGEMENT FOR PROJECTOR SUPPORTING FIXTURE AND SPRING

inside of the circle subtends an angle of minutes of arcat a point situated at '*x*' metres [Fig. 15 (b)], where

η is the limit value of Secondary-Image Separation,

'*x*' is the distance from windscreen to the target (not less than 7 m), and

D is given by the formula, $D = x.\ \tan(\eta)$

6.13.1.1.3 The illuminated target consists of a light box, 300 mm × 300 mm × 150 mm.

6.13.1.2 *Procedure*

6.13.1.2.1 Mount the windscreen at the angle of inclination on a suitable stand in such a way that the observation is carried out in the horizontal plane passing through the centre of the target.

6.13.1.2.2 The light box shall be viewed, in a dark or semi-dark room, through each part of the area being examined, in order to detect the presence of

any secondary image associated with the illuminated target.

6.13.1.2.3 Rotate the windscreen as necessary to ensure that the correct direction of view is maintained. A monocular may be used for viewing.

6.13.1.3 *Expression of results* — Determine whether:

6.13.1.3.1 When target (a) [Fig. 15(a)] is used, the primary and secondary images of the circle separate, that is, whether the limit value of η is exceeded, or

6.13.1.3.2 When target (b) [Fig. 15 (b)] is used, the secondary image of the spot shifts beyond the point of tangency with the inside edge of the circle, that is, whether the limit value of is exceeded.

6.13.2 *Alternative Collimation-Telescope Test*

6.13.2.1 *Apparatus*

6.13.2.1.1 The apparatus comprises a collimator and a telescope and may be set up in accordance with Fig. 16. However, any equivalent optical system may be used.

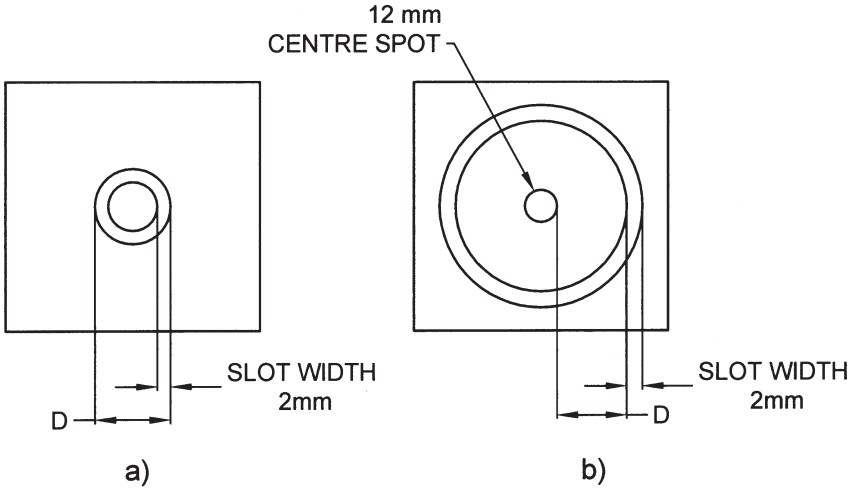
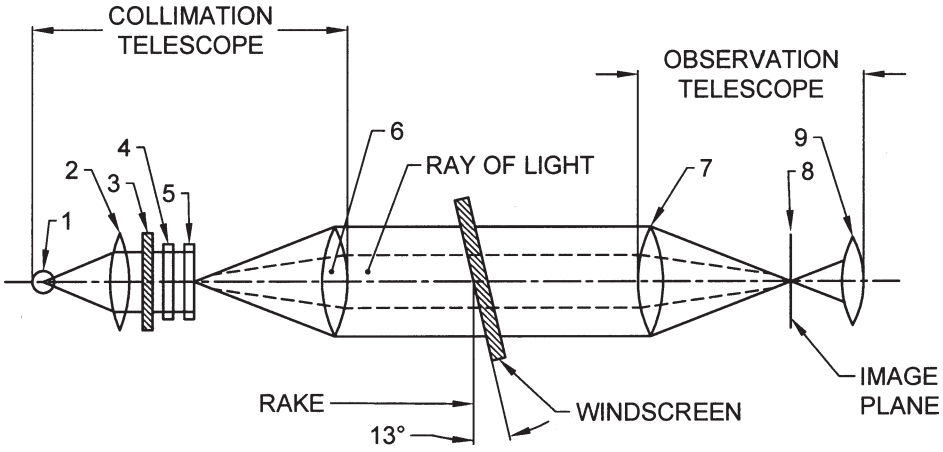


FIG. 15 DIMENSIONS OF TARGETS



1 — Lamp
2 — Condenser aperture > 8.6 mm.
3 — Ground-glass screen aperture > condenser aperture.
4 — Colour filter with central hole approximately 0.3 mm in diameter, diameter > 8.6 mm.
5 — Polar co-ordinate plate, diameter > 8.6 mm.
6 — Achromatic lens, $f \geq 8.6$ mm, aperture 10 mm.
7 — Achromatic lens, $f \geq 8.6$ mm, aperture 10 mm.
8 — Black spot, diameter approximately 0.3 mm.
9 — Achromatic lens, $f = 20$ mm, aperture < 10 mm.

FIG. 16 APPARATUS FOR COLLIMATION-TELESCOPE TEST

6.13.2.2 *Procedure*

6.13.2.2.1 The collimation telescope forms at infinity the image of a polar co-ordinate system with a bright point at its centre (*see* Fig. 17).

6.13.2.2.2 In the focal plane of the observation telescope, a small opaque spot with a diameter slightly larger than that of the projected bright point is placed on the optical axis, thus obscuring the bright point.

6.13.2.2.3 When a test piece which exhibits a secondary image is placed between the telescope and the collimator, a second, less bright point appears at a certain distance from the centre of the polar co-ordinate system. The secondary-image separation can be read out as the distance between the points seen through the observation telescope (*see* Fig. 17).

6.13.2.2.4 The distance between the dark spot and the bright point at the centre of the polar co-ordinate system represents the optical deviation.

6.13.2.3 *Expression of results*

The windscreen shall first be examined by a simple scanning technique to establish the area giving the strongest secondary image.

That area shall then be examined by the collimator-telescope system at the appropriate angle of incidence. The maximum secondary-image separation shall be measured.

6.13.3 The direction of observation in the horizontal plane shall be maintained approximately normal to the trace of the windscreen in that plane.

6.13.4 *Test Pieces*

6.13.4.1 The test pieces shall be windscreens.

6.13.5 *Alternate Test Method for Secondary Image Separation Test*

The test shall be carried out with the test piece at the designed angle of rake from the vertical in a dark room so that secondary image and the white circle shall be distinctly visible.

6.13.5.1 *Apparatus*

The apparatus shall consist of a box 30 cm × 30 cm × 15 cm as shown in Fig. 18 . The front of the box shall have either a central hole of 12.7 mm diameter and a concentric slit of inside diameter 7.92 cm and width 1.6 mm forming a 'ring and spot' target or a circular slit of inside diameter 3.33 cm and width 1.6 mm forming a ring target. This front panel may be of glass masked with opaque black paper or of metal sheet painted matt black; in the latter case, the spiders bridging the slit should be small and disposed at 45″ to the vertical and horizontal axes. The box shall be

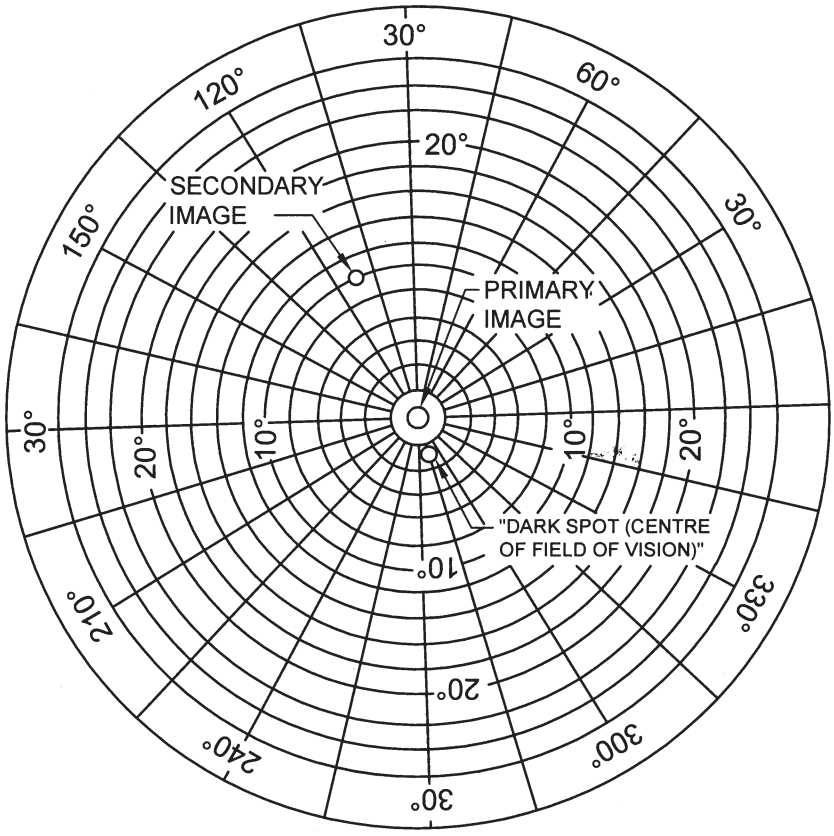


FIG. 17 EXAMPLE OF OBSERVATION BY THE COLLIMATION-TELESCOPE TEST METHOD

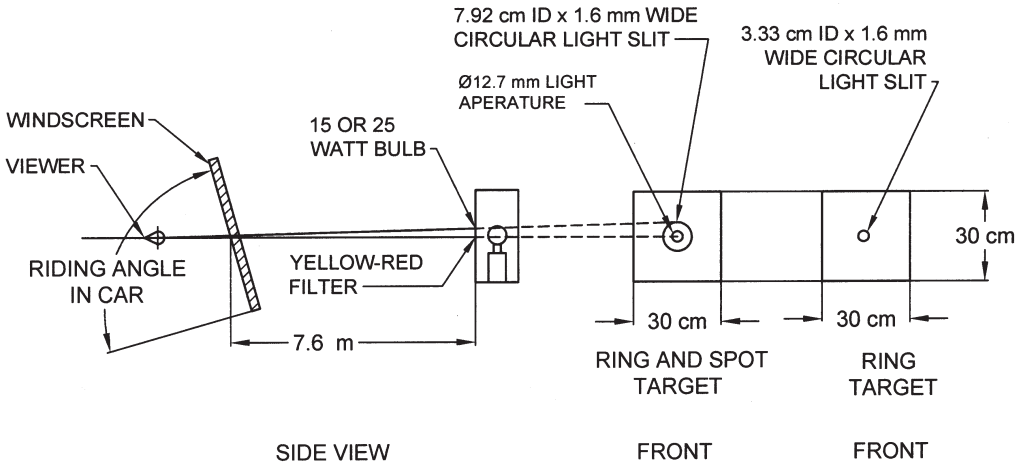


FIG. 18 SECONDARY IMAGE TEST

illuminated by a 15 or 25 watt pearl bulb and the central hole shall be covered by a yellow-red filter, for example, 'Ilford red 608'. The inside of the box shall be painted white.

6.13.5.2 *Procedure*

Place the light box so that the centre of the target lies on a horizontal line passing through the centre of the windscreen placed at a distance of 7.6 m from the light box, either set at the designed rake angle or in a vehicle standing on a level surface facing the light box. View the light box through. Each part of the primary vision area in order to detect the presence of any secondary image associated with the illuminated target. The windscreen may be moved laterally across the projection line, being rotated as necessary to maintain normality of vision in the horizontal plane, still maintaining a distance of 7.6 m from light box to windscreen, and the designed rake angle. A monocular (X2) will assist in viewing and decrease eye strain.

6.13.5.3 *Interpretation of the Result*

a) Using the 'ring and spot' target, there shal1 be no displacement of the secondary image beyond the point of tangency of the central spot image with the inside edge of the circle. This limits the secondary image separation to a maximum of 15 minutes of arc.

b) Alternatively, using the 'ring' target the primary and secondary images of the circle shall either overlap or touch. This also limits the secondary image separation to a maximum of 15 minutes of arc.

c) There shall not be more than one secondary image.

d) From point to point in the test area, there shall be no abrupt change in the displacement of the secondary image.

6.14 Fire Resistance Test

6.14.1 *Apparatus*

6.14.1.1 *Combustion chamber*

6.14.1.1.1 The combustion chamber is illustrated by Fig. 19, having the dimensions given in Fig. 20.

6.14.1.1.2 The combustion chamber is constructed of stainless steel.

6.14.1.1.3 The front of the chamber contains a flame-resistant observation window, which may cover the entire front and which can be constructed as an access panel.

6.14.1.1.4 The bottom of the chamber has vent holes, and the top has a vent slot all around.

6.14.1.1.5 The combustion chamber is placed on four feet, 10 mm high. The chamber may have a hole at one end for the introduction of the sample holder containing the sample; in the opposite end, a hole is provided for the gas-supply line. Melted material is caught in a pan (*see* Fig. 21) which is placed on the bottom of the chamber between vent holes without covering any vent-hole area.

6.14.1.2 *Sample holder*

6.14.1.2.1 The sample holder consists of two U-shaped metal plates or frames of corrosion proof material. Dimensions are given in Fig. 22.

6.14.1.2.2 The lower plate is equipped with pins and the upper one with corresponding holes, in order to ensure a consistent holding of the sample. The pins also serve as measuring points at the beginning and end of the burning distance.

6.14.1.2.3 A support shall be provided in the form of heat-resistant wires 0.25 mm in diameter spanning the frame at 25 mm intervals over the bottom U-shaped frame (*see* Fig. 23).

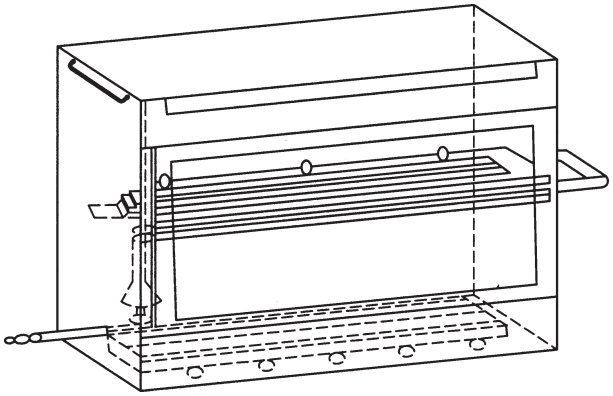
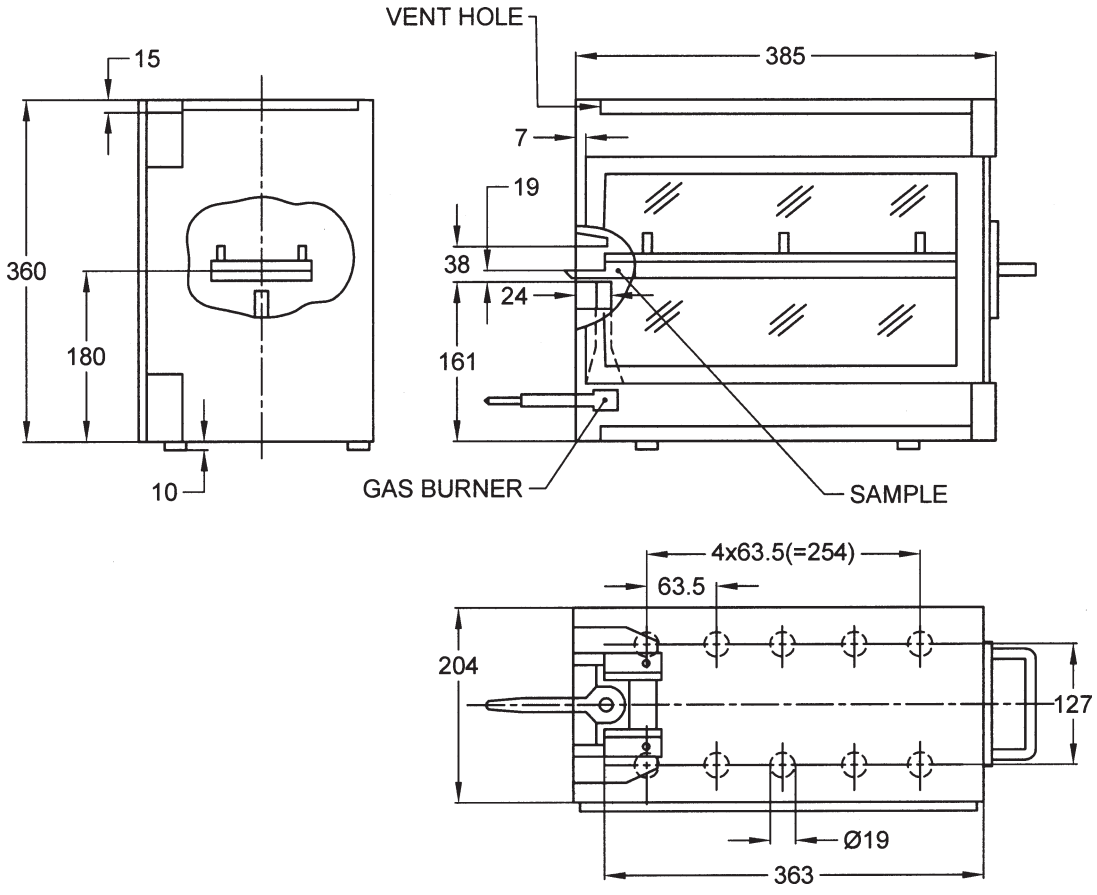


FIG. 19 EXAMPLE OF COMBUSTION CHAMBER WITH SAMPLE HOLDER AND DRIP PAN



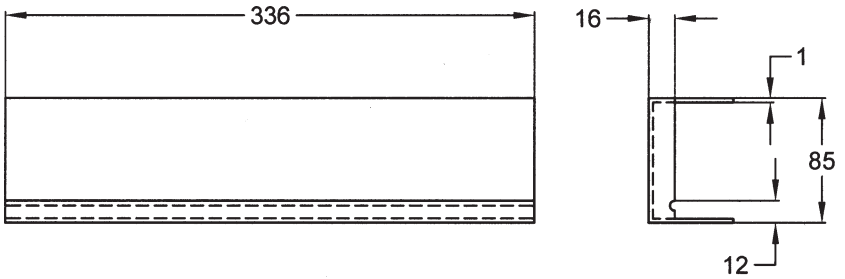
All dimensions in millimetres.

FIG. 20 EXAMPLE OF COMBUSTION CHAMBER

6.14.1.2.4 The plane of the lower side of samples shall be 178 mm above the floor plate. The distance of the front edge of the sample holder from the end of the chamber shall be 22 mm; the distance of the longitudinal sides of the sample holder from the sides of the chamber shall be 50 mm (all inside dimensions) (*see* Fig. 19 and Fig. 20).

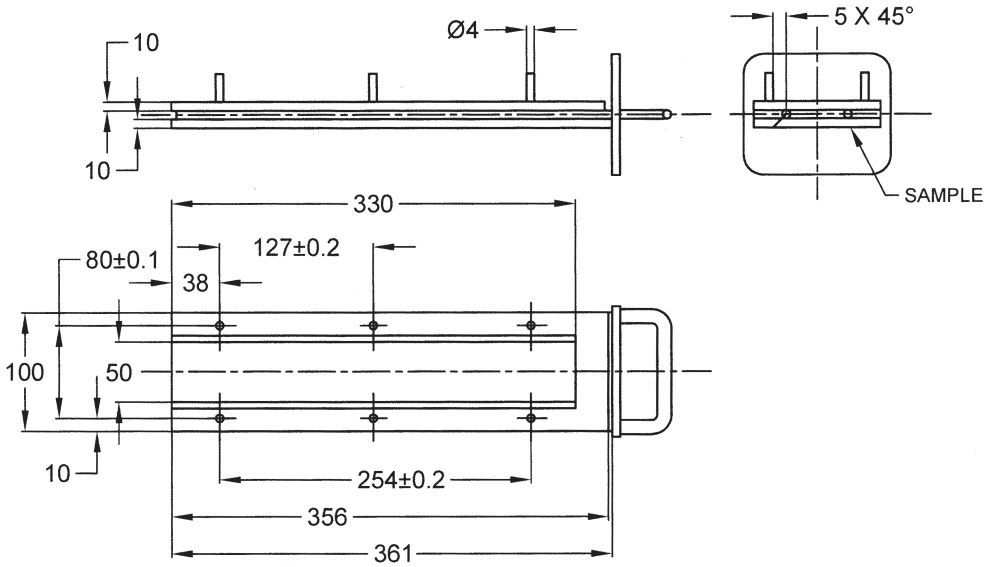
6.14.1.3 *Gas burner*

The small ignition source is provided by a Bunsen burner having an inside diameter of 9.5 mm. It is so located in the test cabinet that the centre of its nozzle is 19 mm below the centre of the bottom edge of the open end of the sample (*see* Fig. 20).



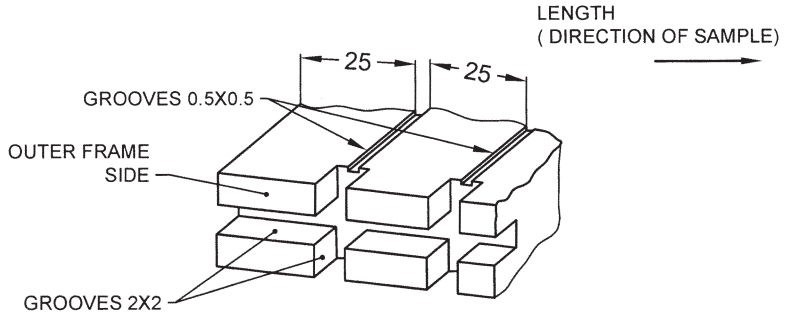
All dimensions in millimetres.

FIG. 21 TYPICAL DRIP PAN



All dimensions in millimetres.

FIG. 22 EXAMPLE OF SAMPLE HOLDER



All dimensions in millimetres (Tolerance as per ISO 2768).

FIG. 23 EXAMPLE OF SECTION OF LOWER U-FRAME DESIGN FOR WIRE SUPPORT FACILITY

6.14.1.4 *Test gas*

The gas supplied to the burner shall have a calorific value of about 38 MJ/m^3 (for example natural gas).

6.14.1.5 Metal comb, at least 110 mm in length, with seven or eight smooth rounded teeth per 25 mm.

6.14.1.6 Stop-watch, accurate to 0.5 s.

6.14.1.7 *Fume-cupboard*

6.14.1.7.1 The combustion chamber may be placed in a fume-cupboard assembly provided that the latter internal volume is at least 20 times, but not more than 110 times greater than the volume of the combustion chamber and provided that no single height, width, or length dimension of the fume cupboard is greater than 2.5 times either of the other two dimensions.

6.14.1.7.2 Before the test, the vertical velocity of the air through the fume-cupboard shall be measured 100 mm forward of and to the rear of the ultimate site of the combustion chamber.

It shall be between 0.10 and 0.30 m/s in order to avoid possible discomfort to the operator from combustion products. It is possible to use a fume cupboard with natural ventilation and an appropriate air velocity.

6.14.2 *Procedure*

6.14.2.1 *Conditioning*

The samples shall be conditioned for at least 24 h, but not more than 7 days, at a temperature of 20 ± 5 °C and a relative humidity of 60 ± 20 per cent and shall be maintained under these conditions until immediately prior to testing.

6.14.2.2 Place samples with napped or tufted surfaces on a flat surface, and comb twice against the nap using the comb (*see* **6.14.1.5**).

6.14.2.3 So place the sample in the sample holder (*see* **6.14.1.2.1**) that the inner side faces downwards, towards the flame.

6.14.2.4 Adjust the gas flame to a height of 38 mm using the mark in the chamber, the air intake of the burner being closed. The flame shall burn for at least 1 min, for stabilization, before the first test is started.

6.14.2.5 Push the sample holder into the combustion chamber so that the end of the sample is exposed to the flame, and after 15 s cut off the gas flow.

6.14.2.6 Measurement of burning time starts at the moment when the foot of the flame passes the first measuring point. Observe the flame propagation on the side (upper or lower) whichever burns faster.

6.14.2.7 Measurement of burning time is completed when the flame has come to the last measuring point or when the flame is extinguished before reaching that point. If the flame does not reach the last measuring point, measure the burnt distance up to the point where the flame was extinguished. Burnt distance is the part of the sample destroyed, on the surface or inside, by burning.

6.14.2.8 If the sample does not ignite or does not continue burning after the burner has been extinguished, or the flame goes out before reaching the first measuring point, so that no burning time is measured, note in the test report that the burning rate is 0 mm/min.

6.14.2.9 When running a series of tests or performing repeat tests, make sure before starting a test that the temperature of the combustion chamber and sample holder does not exceed 30 °C.

6.14.2.10 *Calculation*

The burning rate B, in millimetres per minute, is given by the following formula:

$$B = \frac{s}{t} \times 60$$

where

s = burnt distance, in millimetres; and

t = time in s, taken to burn the distance.

6.14.3 *Test Pieces*

6.14.3.1 *Shape and dimensions*

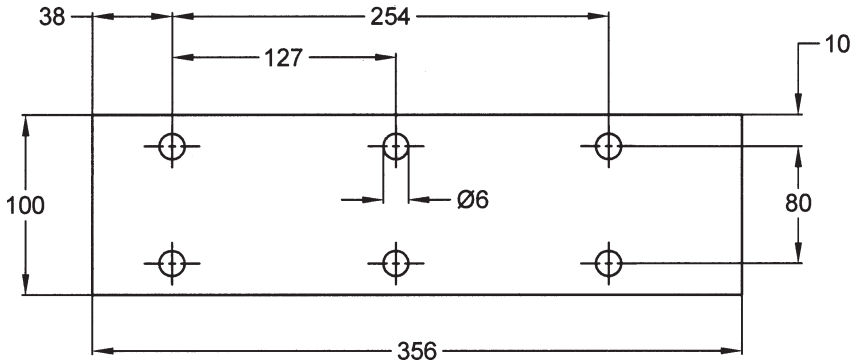
6.14.3.1.1 The shape and dimensions of samples are given in Fig. 24. The thickness of the sample corresponds to the thickness of the product to be tested. It shall not be more than 13 mm. When sample-taking so permits, the sample shall have a constant section over its entire length.

6.14.3.1.2 When the shape and dimensions of a product do not permit taking a sample of the given size, the following minimum dimensions shall be observed:

a) For samples having a width of 3 mm to 60 mm, the length shall be 356 mm. In this case the material is tested over the product width;

b) For samples having a width of 60 mm to 100 mm, the length shall be at least 138 mm. In this case the potential burning distance corresponds to the length of the sample, the measurement starting at the first measuring point;

c) Samples less than 60 mm wide and less than 356 mm long, and samples 60 to 100 mm wide and less than 138 mm long, cannot be tested according to the present method, nor can samples less than 3 mm wide.



All dimensions in millimetres.

FIG. 24 SAMPLE

6.14.3.2 *Sampling*

6.14.3.2.1 Five samples shall be taken from the material under test. In materials having burning rates differing according to the direction of the material (this being established by preliminary tests) the five samples shall be taken and be placed in the test apparatus in such a way that the highest burning rate will be measured.

6.14.3.2.2 When the material is supplied in set widths, a length of at least 500 mm covering the entire width shall be cut. From the piece so cut, the samples shall be taken at not less than 100 mm from the edge of the material and at points equidistant from each other.

6.14.3.2.3 Samples shall be taken in the same way from finished products when the shape of the product so permits. If the thickness of the product is over 13 mm it shall be reduced to 13 mm by a mechanical process applied to the side which does not face the passenger compartment.

6.14.3.2.4 Composite materials shall be tested as if they were homogeneous.

6.14.3.2.5 In the case of materials comprising superimposed layers of different composition which are not composite materials, all the layers of material included within a depth of 13 mm from the surface facing towards the passenger compartment shall be tested individually.

6.15 Test of Resistance to Chemicals

6.15.1 *Chemicals Used for the Test*

6.15.1.1 *Non-abrasive soap solution*

One percent by mass of potassium oleate in deionized water.

6.15.1.2 *Window-cleaning solution*

An aqueous solution of isopropanol and dipropylene glycol monomethyl ether in concentration between 5 and 10 percent by mass each and ammonium hydroxide in concentration between 1 and 5 per cent by mass.

6.15.1.3 *Undiluted denatured alcohol*

One part by volume methyl alcohol in 10 parts by volume ethyl alcohol.

6.15.1.4 *Petrol or Equivalent reference petrol*

A mixture of 50 per cent by volume toluene, 30 per cent by volume 2, 2, 4-trimethylpentane, 15 per cent by volume 2, 4, 4-trimethyl-1-pentene and 5percent by volume ethyl alcohol;

NOTE — The composition of the petrol used shall be recorded in the test report.

6.15.1.5 *Reference kerosene*

A mixture of 50 percent by volume *n*-octane and 50 percent by volume *n*-decane.

6.15.2 *Procedure*

6.15.2.1 *Immersion test*

6.15.2.1.1 Test pieces shall be tested with each of the chemicals specified in **6.15.1** above, using a new test piece for each test and each cleaning product.

6.15.2.1.2 Before each test, test pieces shall be cleaned according to the manufacturer's instruction, and then conditioned for 48 h at the conditions specified in **6.1**. These conditions shall be maintained throughout the tests.

6.15.2.1.3 The test pieces shall be completely immersed in the test fluid and held for one minute, then removed and immediately wiped dry with a clean absorbent cotton cloth.

6.15.2.2 *Test Procedure Under Load — Applicable only for Rigid Plastic Glazing*

6.15.2.2.1 The test specimen shall be simply supported as a horizontal level arm between a fixed supporting edge at one end in such a way that the entire width will rest on a cutting edge (fulcrum) which is 51 mm from the fixed end support. A load shall be suspended from the free end of the test specimen at a distance of 102 mm from the fulcrum as shown in the Fig. 25.

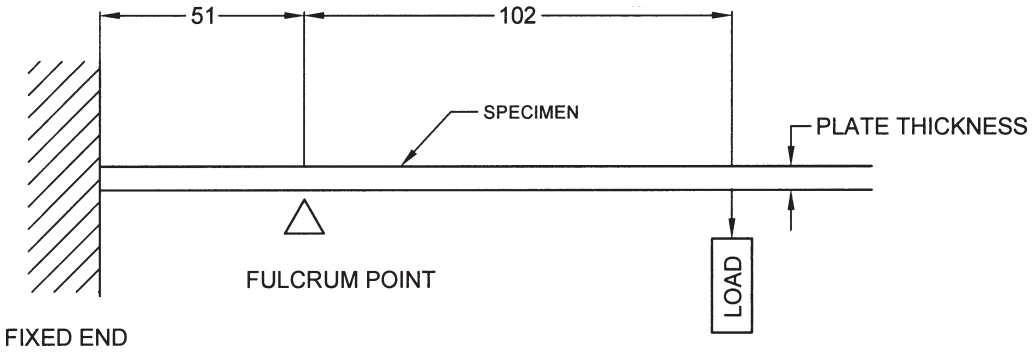
6.15.2.2.2 The load mass shall be 28.7 t^2 g where t is the thickness in mm of the test specimen. The resulting stress on the outer fiber of the test specimen is approximately 6.9 MPa.

Example: For a 3 mm thick test specimen placed horizontally between a downward fixed edge and an upward fulcrum edge separated by 51 mm the applied downward load at 102 mm from the fulcrum is to be 258 g.

6.15.2.2.3 While the test specimen is stressed, one of the prescribed chemicals shall be applied to the top surface of the test specimen above the fulcrum point. The chemical shall be applied with a soft, 13mm wide brush, wetted before each stroke. Ten individual strokes at 1S intervals across the width of the test specimen, avoiding the end and edges, shall be required (*see* Fig. 26).

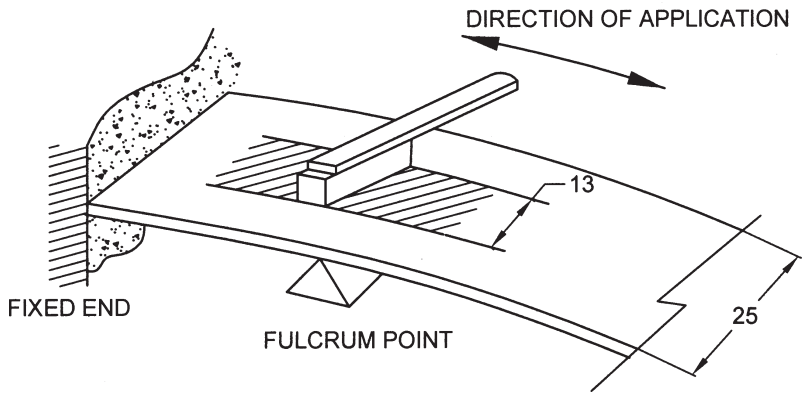
6.15.3 *Test Pieces*

6.15.3.1 The test pieces shall be flat samples measuring 180 mm × 25 mm.



All dimensions in millimetres.

FIG. 25 SUSPENSION OF LOAD



All dimensions in millimetres.

FIG. 26 APPLICATION OF CHEMICAL

6.16 Head Form Test with Deceleration Measurement for Plastic Glazing

6.16.1 *Apparatus*

In the case of head form tests with simultaneous determination of HIC-values the drop body is the phantom head as shown in Fig. 27. The total mass of the phantom head should be 10.0 + 0.2 /-0.0 kg.

In the middle of the base plate (24), the triaxial mounting block (26) is mounted in the center of gravity to receive the acceleration gauges (27). The acceleration gauges should be arranged vertically to each other.

The basin (18) and cover (19) situated under the baseplate (24) share, to a great extent, the elastic properties of the human skull. The elastic properties of the phantom head on impact are determined by the hardness and thickness of the intermediate ring (13) and the basin.

List of pieces for the 10 kg headform concerning Fig.27 is given in Table 3.

6.16.2 *Adjustment and Calibration*

To perform the headform test, the phantom head is fixed to the cross-arm of the guide system (*see* Fig. 28) and moved to the required drop height by means of a lifting device. During the headform test, the cross arm with the phantom head is released. After passing the height adjustable light barrier the phantom head is released from the cross-arm, the cross-arm's fall is dampened and the phantom head falls onto the sample.

No impulse may be given to the phantom head by the drop appliance or by the measuring cable, so that it is accelerated only by gravity and falls vertically.

6.16.2.1 Measuring device which allows to determine HIC-values with the headform described in **6.16.1**.

6.16.2.2 *Equipment to Calibrate the Phantom Head*

The drop appliance must allow drop heights between 50 mm and 254 mm to be adjusted exactly to within 1 mm. A guide system is not necessary for these small drop heights.

A steel impact plate which is made of steel is 600 mm × 600 mm in size and atleast 50 mm thick. The impact surface must be polished.

Surface Roughness R_{max} = 1µm, flatness tolerance t = 0.05 mm.

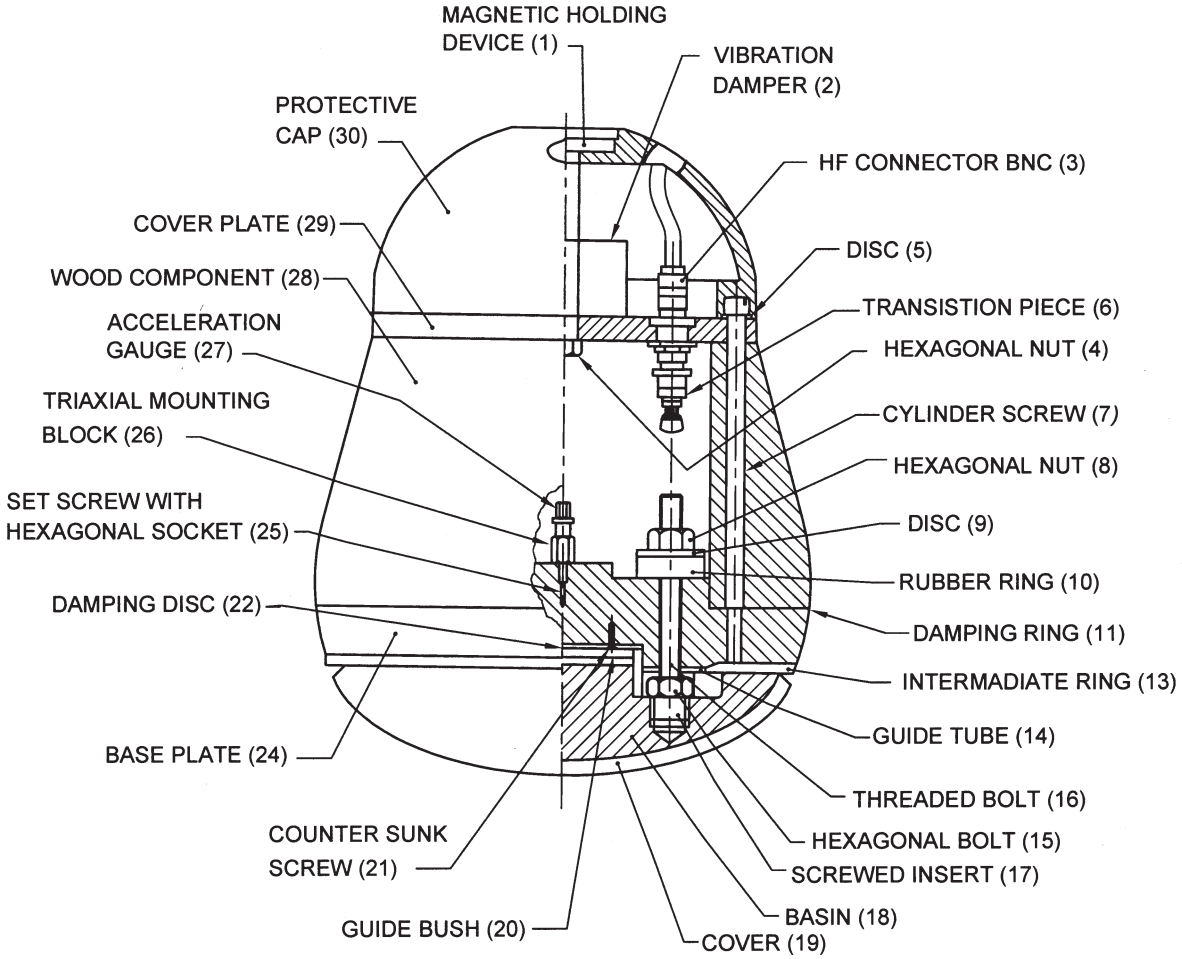


FIG. 27 10 kg HEAD-FORM

6.16.2.3 *Calibration and Adjustment of the Phantom Head*

Before each test series and no later than each 50 tests within a series, the phantom head must be calibrated and adjusted if necessary.

The impact plate must be clean and dry and during the test must lie non-positively on a concrete base.

The phantom head is allowed to hit the impact plate vertically. The drop heights (measured from the lowest point of the phantom head to the surface of the impact plate) are 50, 100, 150 and 254 mm. The deceleration curves should be recorded.

The greatest deceleration a_z from the various drop heights on the z-axis must lie within the limits given below:

Drop Height, mm	*Greatest Deceleration* a_z *as a Multiple of Acceleration Due to Gravity, g*
50	64 ± 5
100	107 ± 5
150	150 ± 7
254	222 ± 12

The deceleration curves should be based on a unimodal vibration. The deceleration curve of the drop height of 254 mm must run atleast 1.2 ms and at most 1.5 ms over 100 g.

If the requirements given above are not met, the elastic properties of the phantom head must be adjusted by varying the thickness of the intermediate ring (13) in the base plate (24). The rubber rings (10) under the hexagon nuts (8) should not be brittle or cracked.

The cover (19) of the impact surface and the intermediate ring (13) should always be replaced immediately if damaged, especially when the phantom head can no longer be adjusted.

6.16.2.4 Supporting fixture for testing flat test pieces as shown in Fig. 27, for testing flat test pieces. The fixture is composed of two steel frames, with machined borders 50 mm wide, fitting one over the other and faced with rubber gaskets about 3mm thick and 15 ± 1 mm wide and of hardness 70 IRHD. The upper frame is held pressed against the lower frame by at least 8 bolts.

Table 3 List of Pieces for the 10 kg Head-form
(*Clause* 6.16.1)

Position No.	Number of Pieces	Standard Notation	Material	Remarks
1	1	Magnetic Holding Device	Steel DIN 17100	
2	1	Vibration Damper	Rubber / Steel	Diameter: 50 mm Thickness: 30 mm Thread: M10
3	4	HF Connector BNC	—	—
4	1	Hexagonal Nut DIN 985	—	—
5	6	Disc DN 125	—	—
6	3	Transition piece	—	—
7	6	Cylinder Screw DIN 912	—	—
8	3	Hexagonal Nut	—	—
9	3	Disc	Steel DIN 17100	Hole Diameter: 8 mm Outer Diameter: 35 mm Thickness: 1.5 mm
10	3	Rubber Ring	Rubber, hardness 60 IRHD	Hole Diameter: 8 mm Outer Diameter: 30 mm Thickness: 10 mm
11	1	Damping Ring	Packing with Paper	Hole Diameter: 120 mm Outer Diameter: 199 mm Thickness: 0.5 mm
12	—	—	—	—
13	1	Intermediate Ring	Butadiene Rubber, Hardness IRHD about 80	Hole Diameter: 129 mm Outer Diameter: 192 mm Thickness: 4 mm
14	3	Guide Tube	Polytetrafluoroethylene (PTFE)	Inner Diameter: 8 mm Outer Diameter: 10 mm Length: 40 mm
15	3	Hexagonal Nut	—	—
16	3	Threaded Bolt DIN 976	—	—
17	3	Screwed Insert	Cast Alloy DIN 1709-GD-CuZn 37Pb	—
18	1	Basin	Polyamide 12	—
19	1	Cover	Butadiene Rubber	Thickness: 6 mm Rib on one side
20	1	Guide Bush	Steel DIN 17100	—
21	4	Counter Sunk Screw	—	—
22	1	Damping Disc	Packing with paper	Diameter: 65 mm Thickness: 0.5 mm
23	—	—	—	—
24	1	Base Plate	Steel DIN 17100	—
25	1	Set Screw with Hexagonal Socket	Class of Strength 45H	—
26	1	Triaxial Mounting Block	—	—
27	3	Acceleration Guage	—	—
28	1	Wood Component	Hornbeam, glued in layers	—
29	1	Cover Plate	Alloy (AlMg5)	—
30	1	Protective Cap	Polyamide 12	—

6.16.3 *Test Conditions*

Temperature : 20 ± 5°C
Pressure : 860 to 1 060 mbar
Relative Humidity : 60 ± 20 percent

6.16.4 Tests on complete panes (used for a drop height between 1.5 m and 3 m). Place the pane freely on a support with an interposed strip of rubber of hardness 70 IRHD and thickness of about 3 mm.

The pane shall be clamped to the supporting structure by means of appropriate devices. The surface of the pane shall be substantially perpendicular to the incident

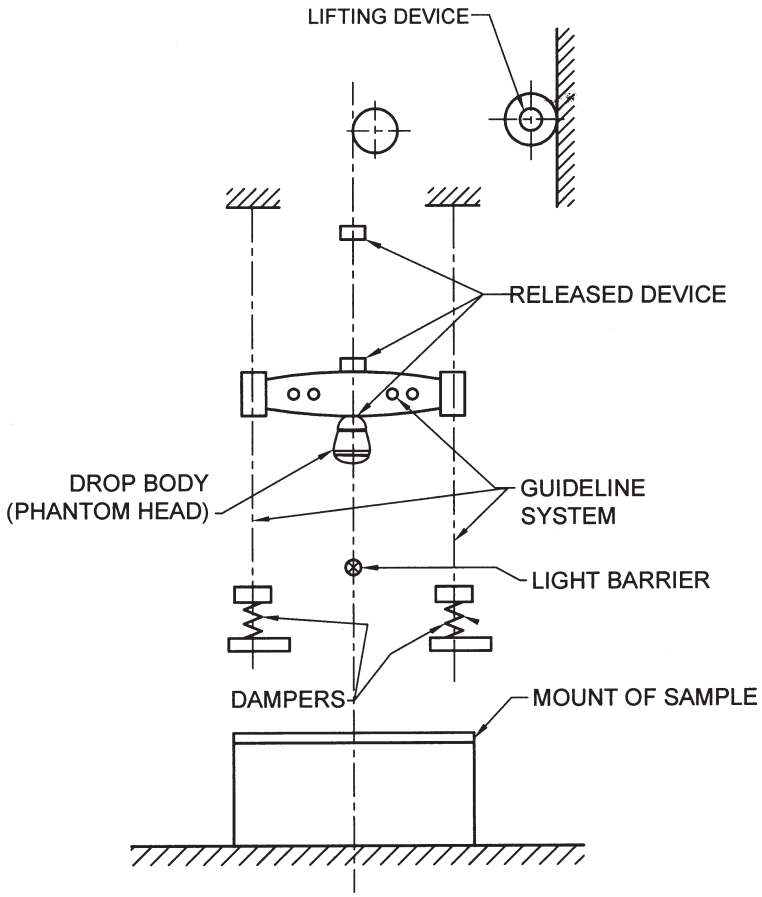


FIG. 28 TEST APPARATUS FOR THE HEAD-FORM EXPERIMENT WITH DECELERATION MEASUREMENT

direction of the headform weight. The headform weight shall strike the pane at a point within 40 mm of its geometric center on that face which represents the inward face of the plastic pane when the latter is mounted on the vehicle, and shall be allowed to make only one impact.

Starting from a selected initial drop height, the drop heights should be raised by 0.5m respectively in each further experiment. The deceleration curves occurring on impact on the sample for a_x, a_y and a_z should be recorded according to time t.

After the headform test, it should be checked whether a glazing edge has moved more than 2mm in the mount and whether the requirement for the point of impact was met. The acceleration components a_x and a_y should be smaller for vertical impact than 0.1 a_z.

6.16.5 *Evaluation*

The deceleration curves should be evaluated as follows:

The resulting deceleration $a_{res}(t)$ in the center of gravity according to equation (1) from the measured deceleration curves $a_x(t)$, $a_y(t)$ and $a_z(t)$ is to be compounded as multiples of the acceleration due to gravity.

$$a_{res}(t) = \left[a_x^2(t) + a_y^2(t) + a_z^2(t) \right]^{1/2} \quad \ldots(1)$$

The time for which a deceleration of 80g with a_{res} is continually exceeded and the greatest deceleration of a_{res} should be determined. The HIC-Value should be calculated as a measurement of the danger of blunt skull-brain-injuries using the following equation (2).

$$HIC = (t_2 - t_1)^{-1.5} \left(\int_{t_1}^{t_2} a_{res}(t) dt \right)^{2.5} \quad \ldots(2)$$

The integral limits t_1 and t_2 should be selected in such a way that the integral takes a maximum value.

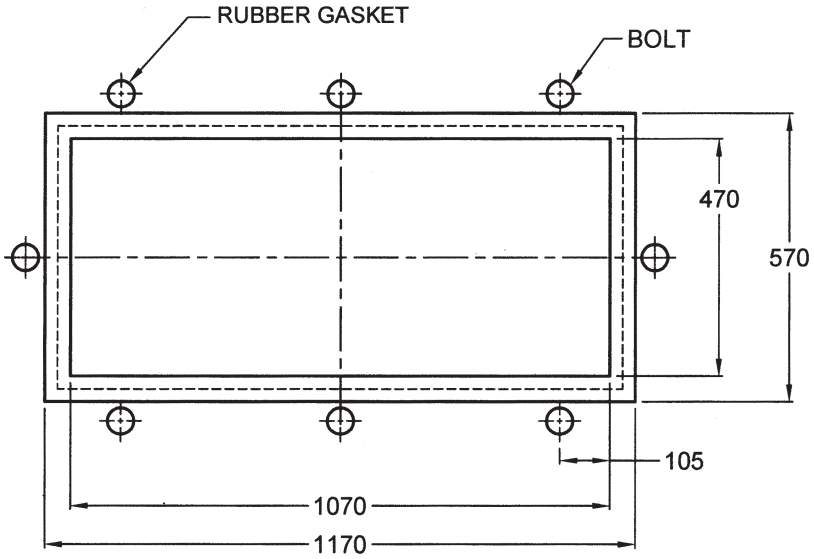
6.17 Flexibility Test and Fold Test

6.17.1 *Scope*

With this test has to be found out whether a plastic is to be classed into the categories of rigid or flexible plastics.

6.17.2 *Test Method*

From the material of the nominal thickness a rectangular flat sample 300 mm long and 25 mm wide is cut out and horizontally clamped into a clamping device in such a way that 275 mm of the length of the sample freely extend over the holding device. This free end shall be supported horizontally by an appropriate device until the test begins. Sixty seconds after removal of this support, the vertical deviation of the free end is indicated in mm. If this deviation exceeds 50 mm a



All dimensions in millimetres.

FIG. 29 SUPPORT FOR HEAD-FORM TEST

180° fold test is performed subsequently. The sample is folded concisely, after that it is folded round 0.5 mm thick piece of sheet metal in such a way that it tightly contacts it on both sides.

6.17.3 *Test Conditions*

Temperature: 20 ± 2°C

Relative Humidity: 60 ± 5 percent

6.17.4 *Requirements*

The vertical deviation must be more than 50 mm for flexible plastics, and 10 s after a 180° — folding, the material must not show any fracture-like damages at the point of buckling (Fig. 30).

6.18 Weathering

6.18.1 *Apparatus*

6.18.1.1 *Long-arc xenon lamp*

The exposure apparatus shall utilize a long-arc xenon lamp as the source of irradiation, but other methods giving the required level of ultraviolet radiant exposure shall be allowed. The long-arc xenon lamp is advantageous in that it can, when correctly filtered and maintained, yield a spectrum most closely approximating that of natural sunlight. To this end, the quartz xenon burner tube shall be fitted with suitable borosilicate glass optical filter(s). The xenon lamps employed shall be operated, from a suitable 50 or 60 Hz power supply suitable reactance transformers and electrical equipment.

6.18.1.2 The exposing apparatus shall include equipment necessary for measuring and/or controlling the following:

a) Irradiance,
b) Black standard temperature,
c) Water spray, and
d) Operating schedule or cycle.

The exposure apparatus shall be made from inert materials which do not contaminate the water employed in the test.

Irradiance shall be measured at the test specimen surface and shall be controlled according to the recommendations of the exposure apparatus manufacturer.

Total Ultraviolet Radiant Exposure (J/m^2) shall be measured or computed and shall be considered the primary measure of test specimen exposure.

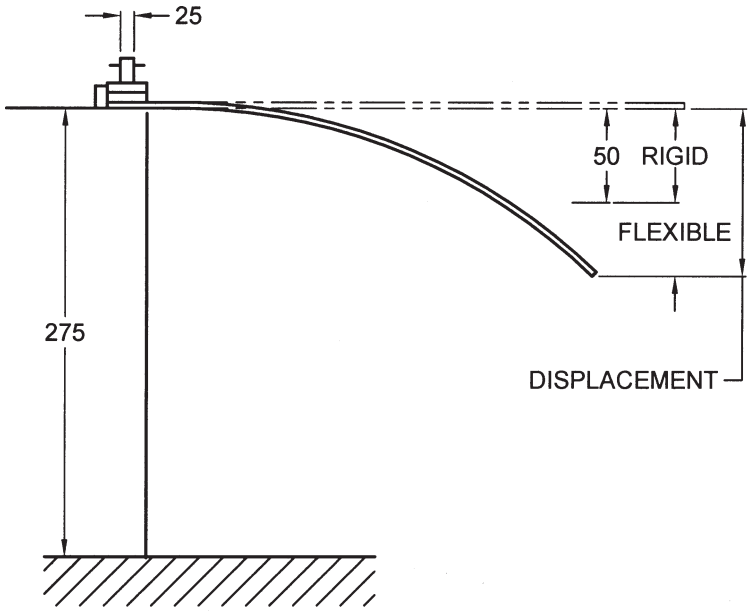
NOTE — Total Ultraviolet is considered to be all radiation of wavelength less than 400 nm.

6.18.1.3 *Test specimens*

The dimensions of the test specimen shall normally be those specified in the appropriate test method for the property or properties to be measured after exposure.

The number of control and test specimens for each test condition or exposure stage shall be determined, in addition to those required for visual evaluations by the number required by the test methods.

It is recommended that visual evaluations be conducted on the largest test specimens being tested.



All dimensions in millimetres.

FIG. 30 ARRANGEMENT OF FLEXIBILITY TEST

6.18.1.4 *Procedure*

Measure according to **6.1**, the luminous transmittance of the test specimen(s) to be measured. Measure according to **6.6**, the resistance of abrasion of the surface(s) of the control specimen(s). The face of each test specimen, which would represent the surface glazed to the exterior of the road vehicle, shall face the lamp. Other exposure conditions shall be as follows.

6.18.1.4.1 The irradiance shall not vary more than ±10 percent over the whole test specimen area.

6.18.1.4.2 At appropriate intervals, clean lamp filters by washing with detergent and water. Xenon-arc filters shall be replaced according to the recommendations of the equipment manufacturer.

6.18.1.4.3 The temperature within the exposure apparatus during the dry portion of the cycle shall be controlled by circulation of sufficient air to maintain a constant black standard temperature.

In the Xenon arc exposure apparatus, this temperature shall be 70 ± 3°C as indicated by a black standard thermometer or equivalent.

The black panel thermometer shall be mounted in the test specimen rack and readings shall be taken at the point where maximum heat is developed due to light exposure.

6.18.1.4.4 The relative humidity within the exposure apparatus shall be controlled at 50 ± 5 percent during the dry portions of the cycle.

6.18.1.4.5 The deionized water used in the spray cycle shall contain less than 1ppm silicon dioxide solids and shall leave no permanent deposit or residue on the test specimens which would interfere with subsequent measurements.

6.18.1.4.6 The *p*H of the water shall be between 6.0 and 8.0, and the conductivity shall be less than 5 microsiemens.

6.18.1.4.7 The temperature of water in the line where it enters the exposure apparatus shall be the ambient water temperature.

6.18.1.4.8 The water shall strike the test specimens, in the form of a fine spray in sufficient volume to wet the test specimens uniformly, immediately upon impact.

Water spray will be directed only against the test specimen surface facing the light source. No recirculation of the spray water or immersion of the test specimens in the water shall be permitted.

6.18.1.4.9 The test specimens shall be rotated about the arc in order to provide uniform distribution of the light. All positions in the exposure apparatus shall be filled with test specimens or surrogates to ensure that a uniform temperature distribution is maintained. Test specimens shall be held in frames with backs exposed to the cabinet environment. However, reflections from cabinet walls shall not be permitted to strike the back surface of specimens. If necessary, samples may be backed to block such reflections so long as free circulation of air at the specimen surface is not impeded.

6.18.1.4.10 The exposure apparatus shall be operated to provide continuous light and intermittent water spray in 2 h cycles. Each 2 h cycle shall be divided into periods during which the test specimens are exposed to light without water spray for 102 min and to light with water spray for 18 min.

6.18.1.5 *Evaluation*

After exposure, the test specimens may be cleaned, if necessary, by a practice recommended by their manufacturer to remove any residues present.

Evaluate the exposed test specimens visually with respect to the following properties:

a) Bubbles,
b) Colour,
c) Haze, and
d) Noticeable decomposition.

Measure the luminous transmittance of the exposed specimens.

6.18.1.6 *Expression of Results*

Report visual evaluations of exposed test specimens, comparing the appearance of each with that of the unexposed control.

The luminous transmittance measured must not differ from the original tests on unexposed samples by more than 5 percent.

6.19 Cross-cut Test

6.19.1 *Scope*

The test gives a simple method to determine the adhesion of coatings to the subsurface. The brittleness and other strength characteristics can be evaluated.

6.19.2 *Apparatus*

Cutting tool with 6 blades set at 1 mm apart. A magnifying glass with an enlargement of 2X to examine the cross-cut specimen (Fig. 31).

6.19.3 *Test Method*

Cut through the coating onto the subsurface a pattern with 6 cuts and perpendicular to this another one so that a grid with 25 squares arises (grid-cut).

The cutting tool should be drawn steadily with a speed of 2 to 5 cm/s so that the cuts reach the subsurface but do not penetrate too deeply.

The cutting is conducted in such a way that the two leading heads at the edge of the apparatus touch the

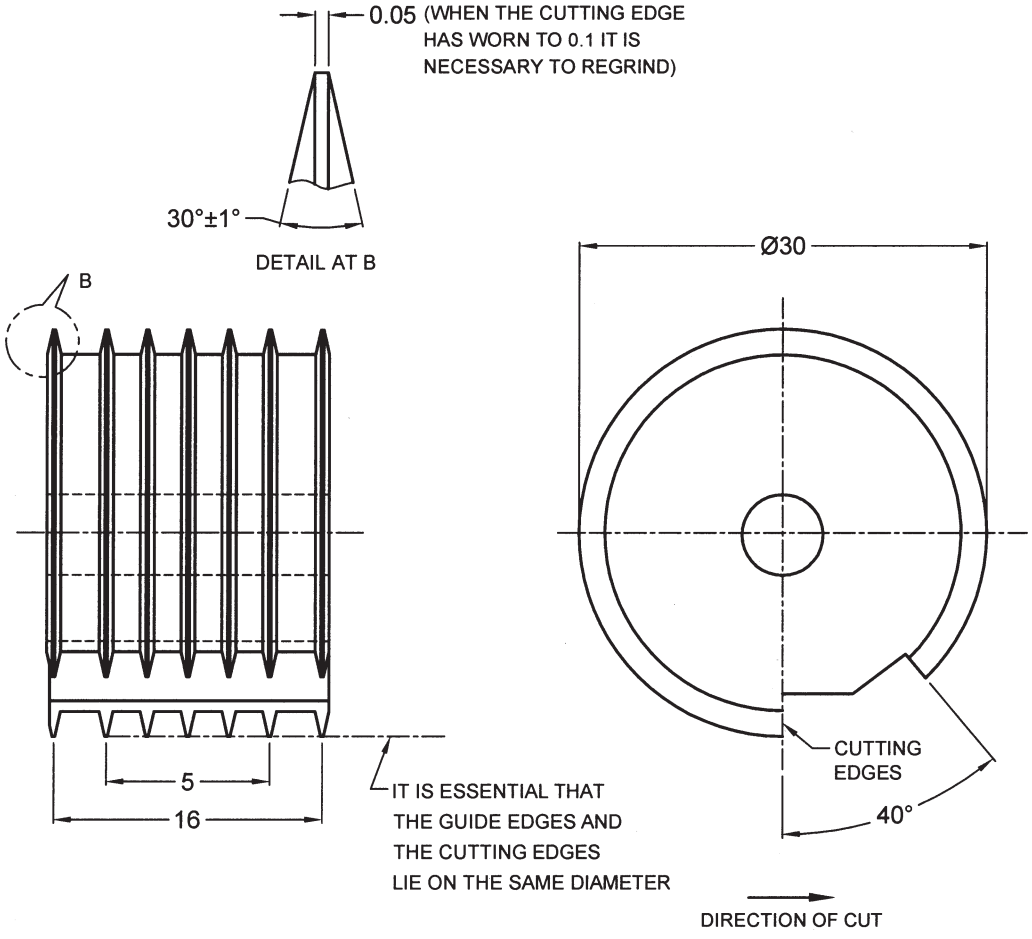


FIG. 31 TOOL WITH SIX BLADES

surface uniformly. After the test, the cuts are examined with a magnifying glass to check that they reach the subsurface. The test is carried out atleast at two different positions of the specimen. After the cuts have been produced, they are brushed five times with slight pressure in both diagonal directions with a hand brush with polyamide bristles.

6.19.4 *Interpretation of Results*

The grid cuts are examined with a magnifying glass. If the cut edges are perfectly smooth and if no part of the coating is detached, then it will be given a cross-cut value of Gt0. If there are small fragments detached at the intersection of the cuts and if the exposed area amounts to about 5percent of the grid area the cut value is Gt1.

Larger areas of detachment will be graded in the range Gt2 to Gt5.

Cut Value Grade	*Exposed Area of the Grid Area*
Gt2	Between 5 and 15 percent
Gt3	Between 15 and 35 percent
Gt4	Between 35 and 65 percent
Gt5	Higher than 65 percent

7 POSITION OF POINTS

7.1 Procedures for determining test areas on windscreens of Category M1and N (derived from a M1 where the windscreen and seating positions are identical) vehicles in relation to the 'V" Points and Category M and N (except M1 and those N derived from a M1 where the windscreen and seating position are identical) vehicles in relation to the "O" point.

7.1.1 *Position of the "V" Points*

7.1.1.1 The position of the "V" points in relation to the "R" point as indicated by the X Y and Z co-ordinates in the three-dimensional reference system, are shown in Table 4 and Table 5.

7.1.1.2 Table 3 gives the basic co-ordinates for a design seat-back angle of 25°. The positive direction of the co-ordinates is shown in Fig. 35.

Table 4 Basic Co-ordinates for V Points
(*Clause* 7.1.1.2)

'V' Point	***A***	***b***	***c*(*d*)**
V_1	68 mm	-5 mm	665 mm
V_2	68 mm	-5 mm	589 mm

7.1.1.3 *Correction for design seat-back angles other than 25°*

7.1.1.3.1 Table 5 shows the further corrections to be made to the X and Z co-ordinates of each "V" point when the design seat-back angle is not 25°. The positive direction of the co-ordinates is shown in Fig. 35.

7.1.2 *Position of the "O" Point*

7.1.2.1 The eye-point "*O*" is the point located 625 mm above the *R*-point in the vertical plane parallel to the longitudinal median plane of the vehicle for which the windscreen is intended, passing through the axis of the steering wheel.

7.1.3 *Test Areas*

The test areas shall be determined as follows:

7.1.3.1 *For optical distortion and image separation measurement*

Table 5 Corrections for *X* and *Z* co-ordinates of V Points
(*Clauses* 7.1.1.1 *and* 7.1.1.3.1)

Seat-back Angle (in °)	**Horizontal Co-ordinates *X***	**Vertical Coordinates *Z***	**Seat-back Angle (in °)**	**Horizontal Co-ordinates *X***	**Vertical Co-ordinates *Z***
(1)	(2)	(3)	(1)	(2)	(3)
5	–186 mm	28 mm	23	–18 mm	5 mm
6	-177 mm	27 mm	24	–9 mm	3 mm
7	–167 mm	27 mm	25	0 mm	0 mm
8	–157 mm	27 mm	26	9 mm	–3 mm
9	–147 mm	26 mm	27	17 mm	–5 mm
10	–137 mm	25 mm	28	26 mm	–8 mm
11	–128 mm	24 mm	29	34 mm	–11 mm
12	–118 mm	23 mm	30	43 mm	–14 mm
13	–109 mm	22 mm	31	51 mm	–18 mm
14	–99 mm	21 mm	32	59 mm	–21 mm
15	–90 mm	20 mm	33	67 mm	–24 mm
16	–81 mm	18 mm	34	76 mm	–28 mm
17	–72 mm	17 mm	35	84 mm	–32 mm
18	–62 mm	15 mm	36	92 mm	–35 mm
19	–53 mm	13 mm	37	100 mm	–39 mm
20	–44 mm	11 mm	38	108 mm	–43 mm
21	–35 mm	9 mm	39	115 mm	–48 mm

In case of category M1 and N (derived from a M1 where the windscreen and seating positions are identical) vehicles according to **7.1.3.3**.

In case of category M and N (except those M1 and N category derived from a M1 where the windscreen and seating position are identical) vehicles according to **7.1.3.4**.

7.1.3.2 *For the measurement of Light Transmittance*

In the case of M1 and N (derived from M1 where the windscreen and seating positions are identical) the test shall be carried out in test area B defined in **7.1.3.3.3** excluding any opaque obscuration impinging on it.

In the case of M and N (except those M1 and N derived from a M1 where the windscreen and seating position are identical) the test shall be carried out in the zone I defined in **7.1.3.4.2**.

7.1.3.3 Determination of two test areas for Category M1 and N (derived from a M1 where the windscreen and seating positions are identical) vehicles using the "V" points.

7.1.3.3.1 'Test area A' is the area on the outer surface of the windscreen bounded by the following four planes extending forward from the "V" points [*see* Fig. 32 and Fig. 36]:

a) A plane parallel to the Y axis passing through V1 and inclined upwards at 3° from the X axis (plane 1);
b) A plane parallel to the Y axis passing through V2 and inclined downwards at 1° from the X axis (plane 2);
c) A vertical plane passing through V1 and V2 and inclined at 13° to the right of the X axis in the case of right-hand drive vehicles and central drive vehicles (plane 3); and
d) A vertical plane passing through V1 and V2 and inclined at 20° to the left of the X axis in the case of right-hand drive vehicles and 13° to the right of the X axis in the case of central drive vehicles (plane 4).

7.1.3.3.2 The "extended test area A" is Zone A, extended to the median plane of the vehicle, and in the corresponding part of the windscreen symmetrical to it about the longitudinal median plane of the vehicle, and also in the reduced test area B according to **7.1.3.3.4**.

7.1.3.3.3 'Test area B' is the area of the outer surface of the windscreen bounded by the intersection of the following four planes (*see* Fig. 33 to 36):

a) A plane inclined upward from the X axis at 7°, passing through V1 and parallel to the Y axis (plane 5);
b) A plane inclined downward from the X axis at 5°, passing through V2 and parallel to the Y axis (plane 6);
c) A vertical plane passing through V1 and V2 and forming an angle of 17° to the right of the X axis in the case of right-hand drive vehicles (plane 7); and
d) A plane symmetrical with respect to the plane 7 in relation to the longitudinal median plane of the vehicle (plane 8).

7.1.3.3.4 The "reduced test area B" is test area B with the exclusion of the following areas (*see* Fig. 33 to Fig. 37):

NOTE — But taking into account the fact that the datum points as defined under **7.1.3.3.5** shall be located in the transparent area.

7.1.3.3.4.1 The test area A defined under **7.1.3.3.1**, extended according to **7.1.3.3**.

7.1.3.3.4.2 At the discretion of the vehicle manufacturer, one of the two following may apply:

7.1.3.3.4.2.1 Any opaque obscuration bounded downwards by plane 1 and laterally by plane 4 and its symmetrical in relation to the longitudinal median plane of the vehicle (plane 4');

7.1.3.3.4.2.2 Any opaque obscuration bounded downwards by plane 1, provided it is inscribed in an area 300 mm wide centered on the longitudinal median plane of the vehicle, and provided the opaque obscuration below the plane 5 trace is inscribed in an area limited laterally by the traces of planes passing by the limits of a 150 mm wide segment and parallel respectively to the traces of planes 4 and 4'.

NOTE — Measured on the outer surface of the windscreen and on the trace of plane 1.

7.1.3.3.4.3 Any opaque obscuration bounded by the intersection of the outer surface of the windscreen:

a) with a plane inclined downwards from the X axis at 4°, passing through V2, and parallel to the Y axis (plane 9);
b) with plane 6; and
c) with planes 7 and 8 or the edge of the outer surface of the windscreen if the intersection of plane 6 with plane 7 (plane 6 with plane 8) does not cross the outer surface of the windscreen.

7.1.3.3.4.4 Any opaque obscuration bounded by the intersection of the outer surface of the windscreen:

a) with a horizontal plane passing through V1 (plane 10).
b) with plane 3.

NOTE — For the other side of the windscreen, with a symmetrical plane with respect to plane 3 in relation to the longitudinal median plane of the vehicle.

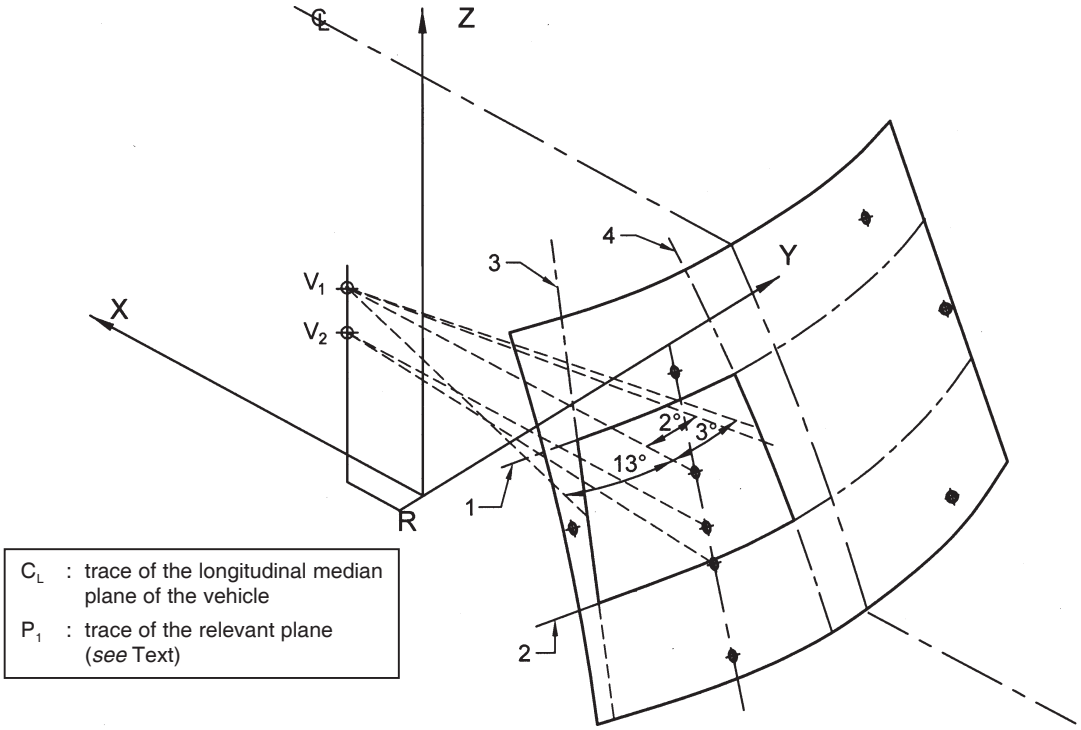


FIG. 32 TEST AREA "A"(EXAMPLE OF A RIGHT-HAND STEERING CONTROL VEHICLE)

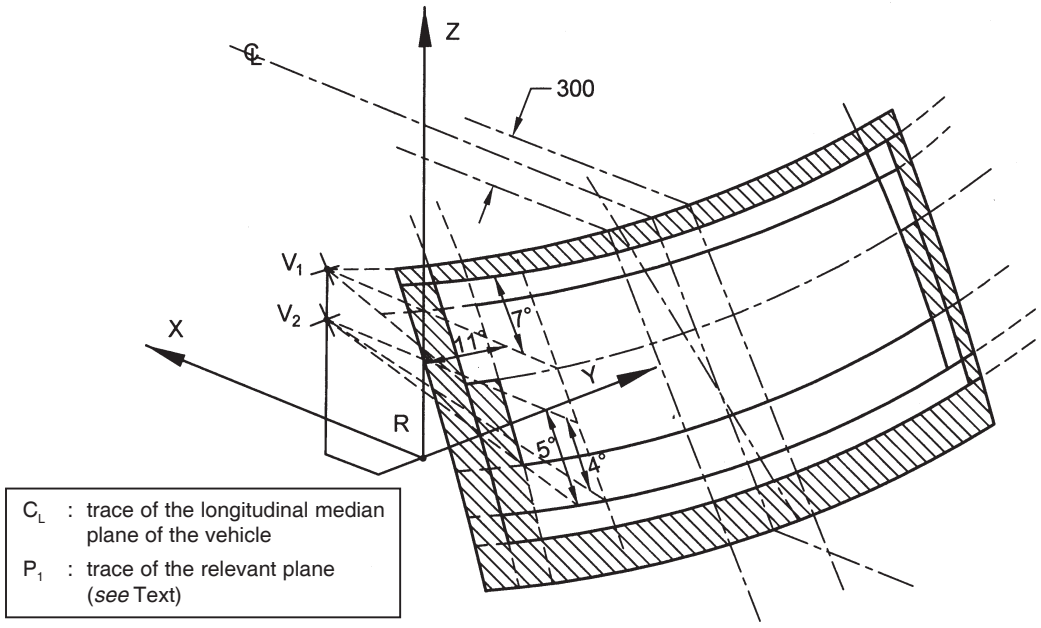


FIG. 33 REDUCED TEST AREA "B" (EXAMPLE OF A RIGHT-HAND STEERING CONTROL VEHICLE) UPPER OBSCURATION AS DEFINED IN **7.1.3.3.4.2.2**

c) with plane 7 or the edge of the outer surface of the windscreen if the intersection of plane 6 with plane 7 (plane 6 with plane 8) does not cross the outer surface of the windscreen;

NOTE — 7 for the other side of the windscreen, with plane 8.

d) with plane 9.

7.1.3.3.4.6 An area within 25 mm from the edge of the outer surface of the windscreen or from any opaque obscuration. This area shall not impinge on the extended test area A.

7.1.3.3.5 *Definition of the Datum Points* (*see* Fig. 37)

The datum points are points situated at the intersection

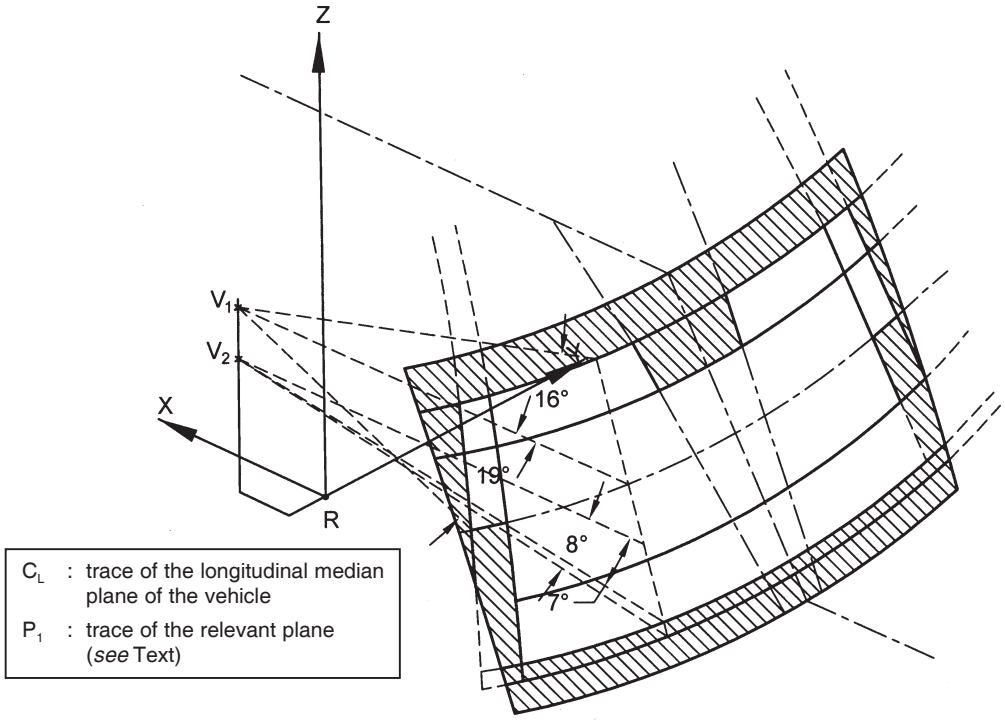


FIG. 34 REDUCED TEST AREA "B" (EXAMPLE OF A RIGHT-HAND STEERING CONTROL VEHICLE) UPPER OBSCURATION AS DEFINED IN **7.1.3.3.4.2.1**

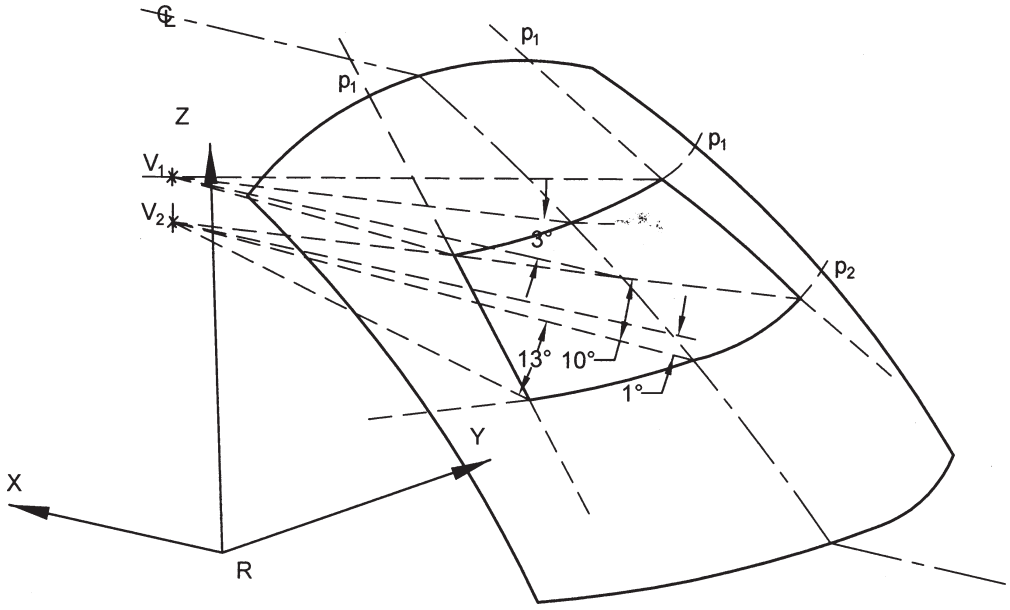


FIG. 35 TEST AREA 'A' (EXAMPLE OF CENTRAL STEERING CONTROL VEHICLE)

with the outer surface of the windscreen of lines radiating forward from the V points:

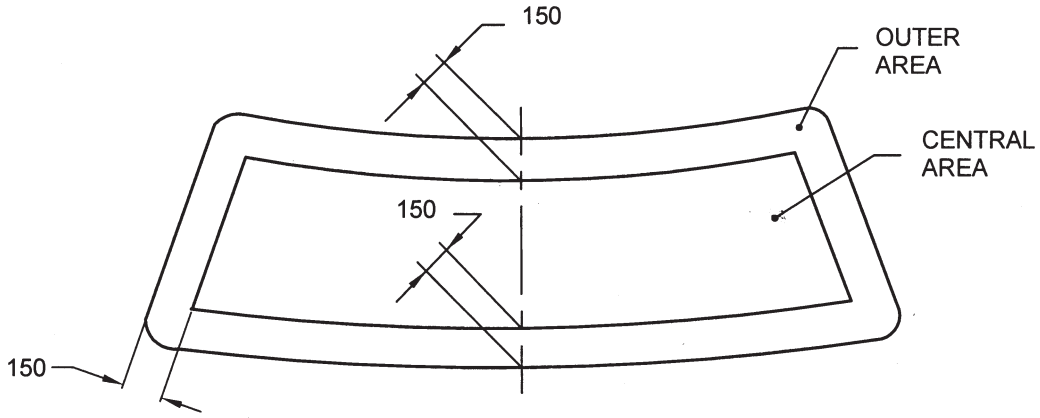
7.1.3.3.5.1 Upper vertical datum point forward of V1 and 7° above the horizontal (Pr1).

7.1.3.3.5.2 Lower vertical datum point forward of V2 and 5° below the horizontal (Pr2).

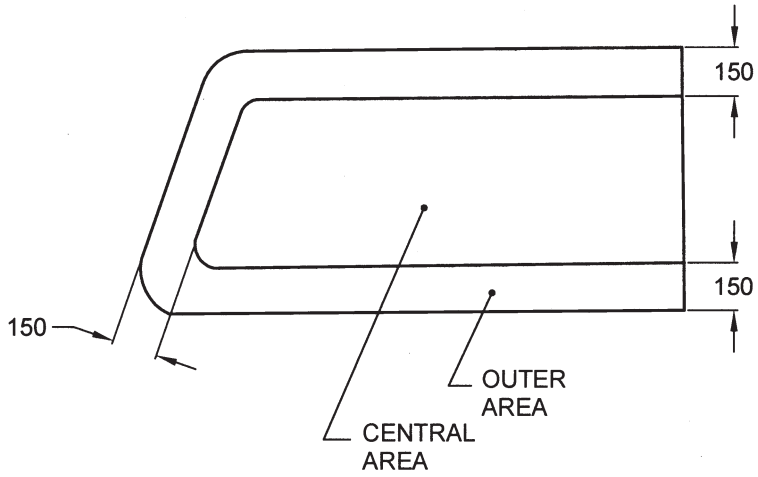
7.1.3.3.5.3 Horizontal datum point forward of V1 and 17° to the right (Pr3).

7.1.3.3.5.4 Three additional datum points symmetrical to the points defined under **7.1.3.3.5.1** to **7.1.3.3.5.3** in relation to the longitudinal median plane of the vehicle (respectively Pr'1, Pr'2, Pr'3).

7.1.3.4 Determination of the Test Areas for Category M and N (except those M1 and N derived from a M1 where the windscreen and seating position are identical) vehicles using the "*O*" point.



36A Central Area and Outer Area of Windscreen



36B Central Area and Outer Area of Divided Windscreen

FIG. 36 CENTRAL AREA AND OUTER AREA OF THE WINDSCREEN

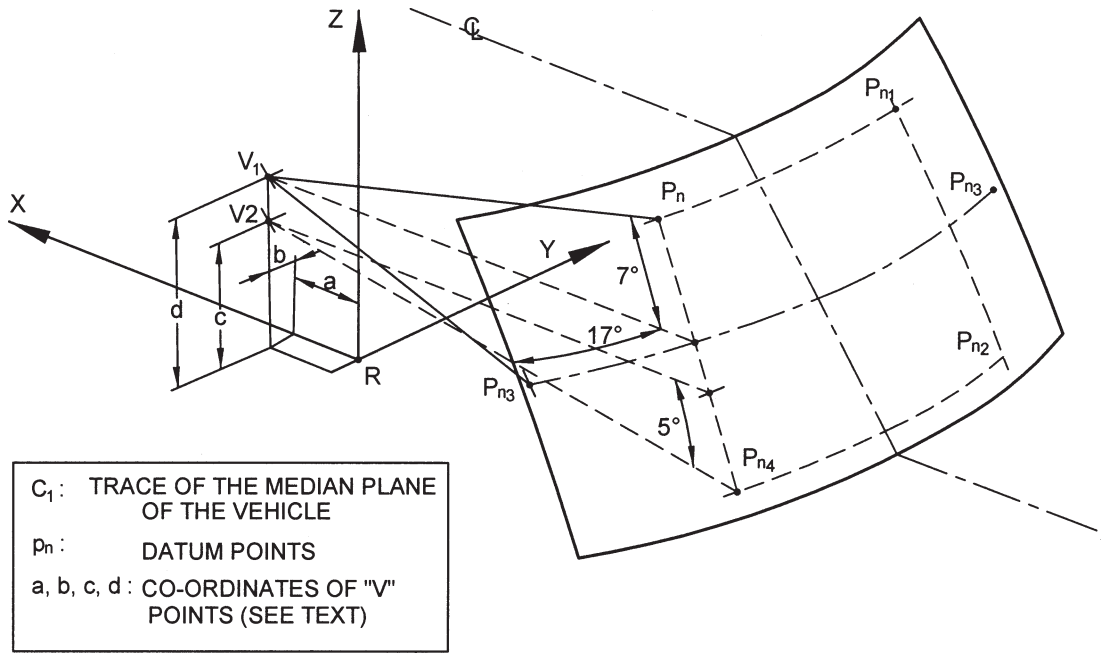


FIG. 37 DETERMINATION OF THE DATUM POINTS (EXAMPLE OF A RIGHT-HAND STEERING CONTROL VEHICLE)

7.1.3.4.1 The straight line *OQ* which is the horizontal straight line passing through the eye point "*O*" and perpendicular to the median longitudinal plane of the vehicle.

7.1.3.4.2 Zone I is the zone determined by the intersection of the windscreen with the four planes defined below (*see* Fig. 38):

a) P_1 a vertical plane passing through O and forming an angle of 15° to the right of the median longitudinal plane of the vehicle;
b) P_2 a vertical plane symmetrical to P_1 about the median longitudinal plane of the vehicle. If this is not possible (in the absence of a symmetrical median longitudinal plane, for instance) P_2 shall be the plane symmetrical to P_1 about the longitudinal plane of the vehicle passing through point *O*.
c) P_3 a plane passing through a transverse horizontal line (line *OQ*) containing *O* and forming an angle of 10° above the horizontal plane.
d) P_4 a plane passing through a transverse horizontal line (line *OQ*) containing *O* and forming an angle of 8° below the horizontal plane.

7.1.4 *Central Area and Outer Area of Wind Screen*

That part of the windscreen through which the principal afield of view is obtained (*see* Fig. 36) is called the central area of windscreen. It is also called primary vision area of the windscreen. The remaining area is considered outer area.

7.2 Measurement of the Height of Segment and Position of the Points of Impact (*see* Fig. 39)

7.2.1 In the case of glazing having a simple curvature, the height of segment will be equal to: h_1 maximum.

7.2.2 In the case of glazing having a double curvature, the height of segment will be equal to: h_1 maximum + h_2 maximum.

7.2.3 Position of prescribed Points of Impact for uniformly toughened glass panes is shown in Fig. 40.

8 APPLICATION FOR TYPE APPROVAL OF SAFETY GLAZING

8.1 Information to be submitted at the time of applying for type approval of safety glazing shall be as given in Annex A.

8.2 The application shall be accompanied with requisite number of samples and/or test pieces.

9 PACKING AND MARKING

9.1 Packing

9.1.1 Safety glass shall be packed as agreed to between purchaser and the supplier.

9.2 Marking

9.2.1 Each piece of safety glass shall comply with the requirements given in **4** and shall also be marked with indication of source of manufacture.

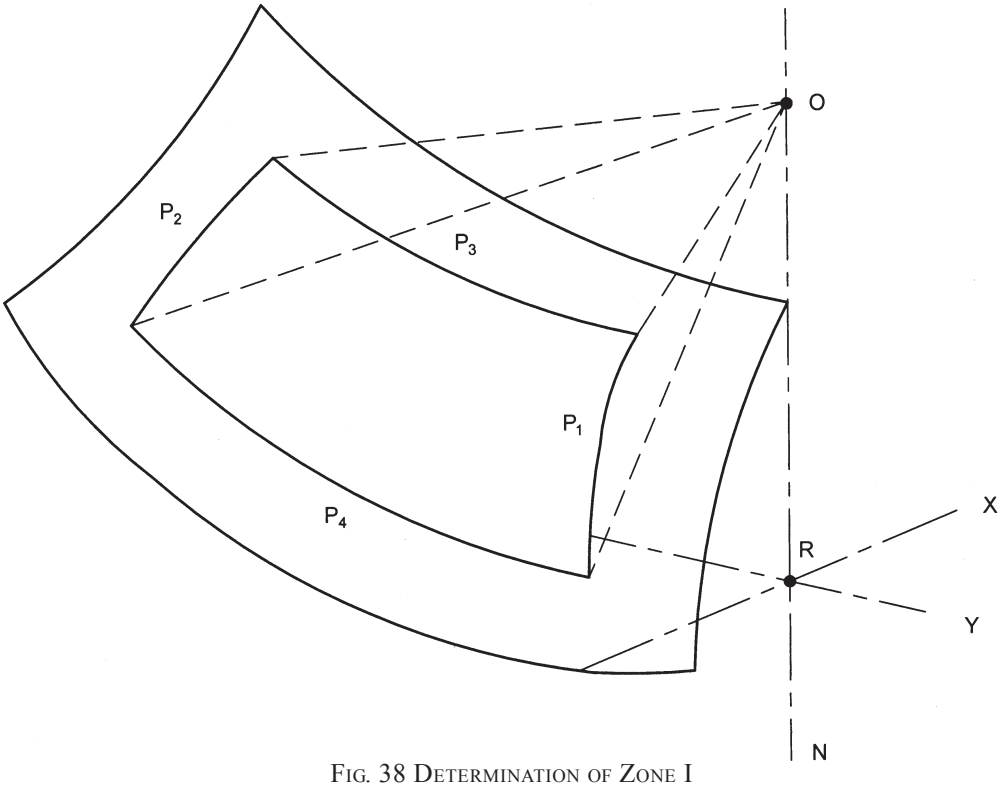


FIG. 38 DETERMINATION OF ZONE I

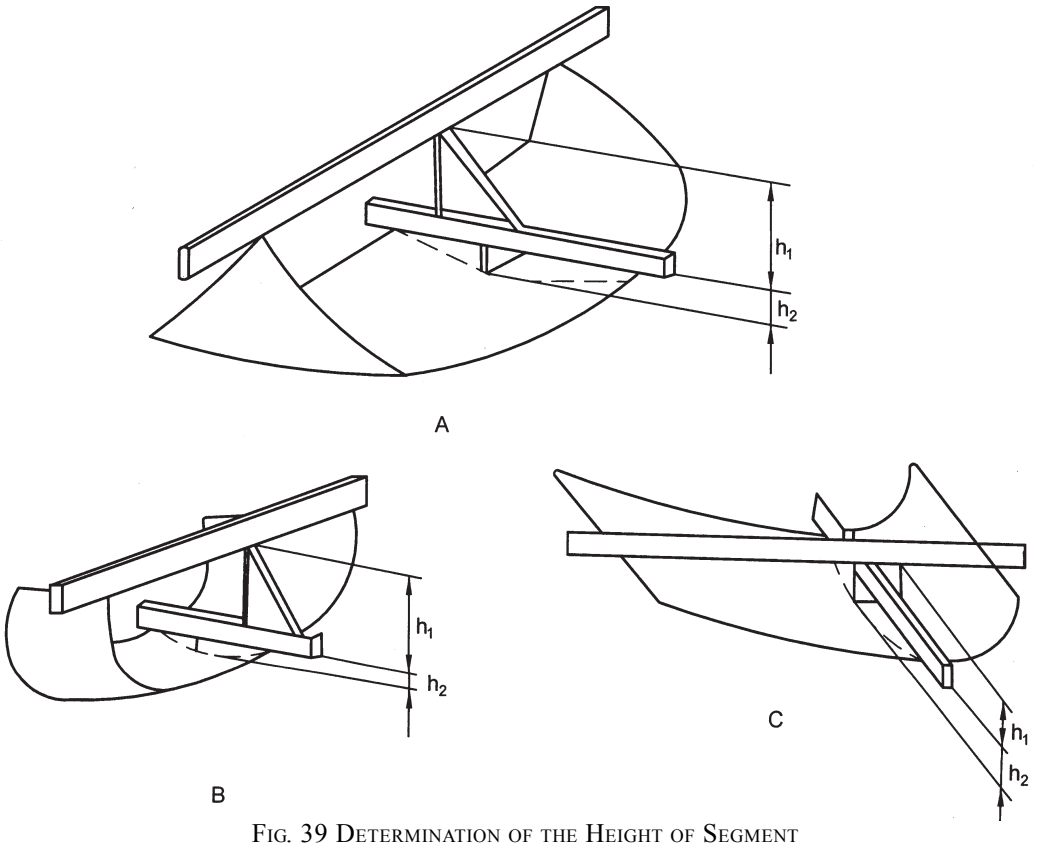


FIG. 39 DETERMINATION OF THE HEIGHT OF SEGMENT

9.2.2 Each packet may be marked with the following information:

a) Indication of the source of manufacture,
b) Nominal thickness,
c) Month and year of manufacture, and
d) Type.

10 CONFORMITY OF PRODUCTION (COP)

10.1 The requirements of COP shall be as specified in **11**.

10.2 Normal frequency of COP shall be 2 years.

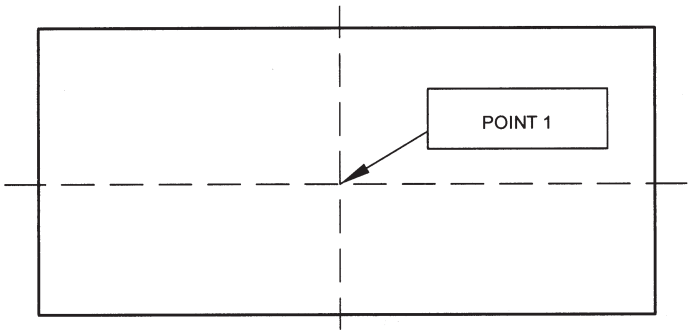
10.3 In case a type approval certificate has already been granted as per IS 2553 (part 2), the same shall be extended as per this standard provided the requirements laid down in **13.1** are complied with.

11 ACCEPTANCE TESTS (CONFORMITY OF PRODUCTION TESTS)

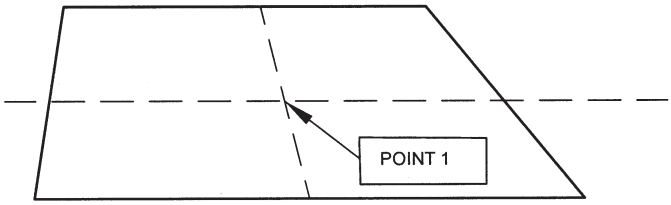
11.1 Following tests shall be done at a frequency of once in two years.

Test	*Windscreens*			*Panes*					
	Laminated Glass		Glass Plastics	Uniformly Toughened Glass		Laminated Glass		Double Glazed unit[1)]	Glass Plastics
Marking	II	II/P	IV	I	/P	XI	XI/P	VI	XII
Light Transmittance	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**	**5.1.1**
Resistance to High Temperature/ Boil Test	**5.3.2**	**5.3.2**	**5.3.2**		**5.3.2**	**5.3.2**	**5.3.2**		**5.3.2**
Optical Distortion	**5.4.1**	**5.4.1**	**5.4.1**						
Secondary Image Separation	**5.4.2**	**5.4.2**	**5.4.2**						
Fragmentation				**5.5.1.1**	**5.5.1.1**				
Head-form Test	**5.4.3**	**5.4.3**	**5.4.3**					**5.5.3.2**	
2 260 g Ball	**5.4.4**	**5.4.4**	**5.4.4**						

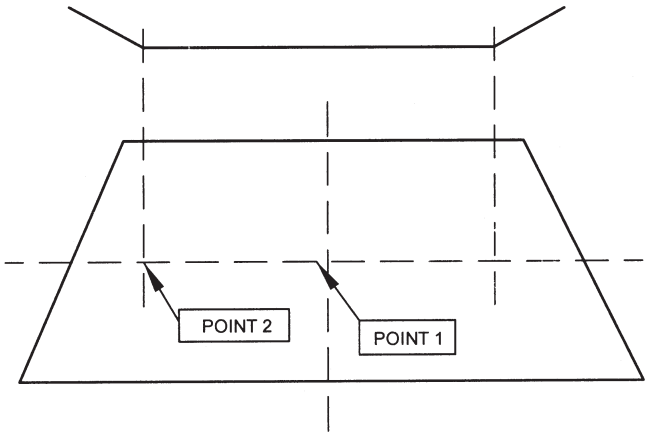
[1)] Each component pane shall satisfy the appropriate tests for the type of glazing.



A FLAT GLASS PANE



B FLAT GLASS PANE



C CURVED GLASS PANE

FIG. 40 PRESCRIBED POINTS OF IMPACT FOR UNIFORMLY TOUGHENED GLASS PANES

12 EXTENSION OF APPROVALS

12.1 Every modification pertaining to the information, even if the changes are not technical in nature declared in accordance with Annex A shall be intimated by the manufacturer to the Testing Agency.

If the changes are in parameters not related to the provisions, no further action need be taken.

If the changes are in parameters related to the provisions, the testing agency, which has issued the certificate of compliance, shall then consider, whether,

a) the safety glazing with the changed specifications still complies with provisions, or

b) any further verification is required to establish compliance.

12.2 For considering whether testing is required or not, guidelines given in **12.5** shall be used.

12.3 In case of **12.1.2**, tests for only those parameters which are affected by the modifications need be carried out.

12.4 In case of fulfillment of criterion of **12.1**(a) or after results of further verification as per **12.1**(b) are satisfactory, the approval of compliance shall be extended for the changes carried out.

12.5 Criteria for Extension of Approval

The criteria shall be as agreed to between the testing agency and applicant or manufacturer.

12.6 The Criterion for Extension of approvals in case of Glass plastic / Glazing Faced with plastic / double glazed shall be as agreed to between the manufacturer and the Test Agency.

13 TRANSITIONAL PROVISIONS

13.1 Type approvals issued for compliance to IS 2553 (Part 2) shall be extended to approval this standard subject to satisfactory compliance of the following:

13.1.1 In case of Double glazed units, Glass Plastics and Glazing faced with plastics, all tests specified in this standard.

13.1.2 *In Case of Windscreen and Window Panes Made of Laminated Glass*

13.1.2.1 *2 260 g ball test*.

13.1.2.2 *Resistance to abrasion*

13.1.2.3 *Test for resistance to humidity*

13.1.3 *In Case of Window Panes Made of Uniformly Toughened Glass*

13.1.3.1 *Fragmentation test (for curved panes only).*

14 BIS CERTIFICATION MARKING

Each piece of safety glass may also be marked with the Standard Mark.

14.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Sl No.	*Parameter / Criteria*	*Whether Verification is Required*
1	Change in Type of Glazing from:	
1.1	Laminated to Glass plastic/Glazing Faced with plastic / Double glazed	All Tests Required.
1.2	Uniformly toughened glass to Glass plastic/Glazing Faced with plastic/Double glazed	Fragmentation Test
2	Change in shape of Windscreen Glazing or Uniformly Toughened Window panes retaining the thickness same	No Verification required.
3	Change in Nominal Thickness of Windscreen:	
3.1	If the thickness is within the tolerance	No Verification Required.
3.2	Increase in Thickness	Optical Distortion, Secondary Image and Light Transmission Tests are Required
3.3	Decrease in Thickness	All tests are required.
4	Change in Rake Angle in case of windscreen	Optical Distortion, Secondary Image separation and Light Transmission tests are Required.
5	Change in location of the ‘R’ / ‘H’ / ‘O’ point w.r.t windscreen as mounted on vehicle.	In case the areas referred to in **5.4.1** and **5.4.2** are reduced maintaining the overall boundaries same, no tests are required. In case the boundaries are shifted and / or area is increased, optical distortion and secondary image separation tests need to be carries out.
6	Change in test area in case the earlier approval is based on Fig. 36:	
6.1	Increase in Area	In case the boundaries are shifted and / or area is increased, optical distortion and secondary image separation tests need to be carries out.
6.2	Decrease in Area	If area is reduced maintaining the overall boundaries same, no tests are required.
7	Change in Colour combination i.e. Cl + Cl or Cl + Green etc	Light Transmission, Optical Distortion and Secondary Image separation Test are Required.

ANNEX A

(*Clause* 8.1)

INFORMATION TO BE SUBMITTED AT THE TIME OF APPLYING FOR TYPE APPROVAL OF SAFETY GLAZING

A-1 Information to be submitted at the time of applying for type approval of safety glazing is given below:

a) Name and Address of the Manufacturer.

b) Manufacturing Plant and Address.

c) Part Number or Unique Identification mark.

d) Intended use (windscreen/rear windscreen/ window pane).

e) Designed thickness of glazing with tolerance.

f) Type of Glazing (laminated / uniformly toughened / Glass plastic / Glazing Faced with plastic / in case of double glazed — Symmetrical or Asymmetrical/ Plastic-Rigid / Plastic-Flexible).

g) Designed Angle of Inclination in case of windscreen.

h) Drawing of the safety glazing in triplicate indicating relevant dimensions and location for marking.

j) Description of Glazing (Clear + Clear, Clear + Green, with shade band).

k) Range of angle of inclination.

Bureau of Indian Standards

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: TED 06 (1060).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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