

British Standard Automobile Series : Specification for Road vehicle safety glass

Série automobile : Spécification du verre de sûreté pour les véhicules routiers

Kraftfahrzeugserie : Spezifikation für Sicherheitsglas für Straßenfahrzeuge

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Foreword

This British Standard has been prepared under the direction of the Automobile Standards Committee and has been aligned with the ECE (Economic Commission for Europe) Regulation . . . (Draft ECE Regulation document TRANS/SC1/WP29/R.112/Rev. 2 and/Corr. 1 and/Corr. 2.)

The standards for safety glass within the United Kingdom have been developed over a number of years, this standard being the latest to be published, but there is still a need to retain the existing British Standards BS 857 : 1967 and BS 5282 : 1975 for replacement safety glass for older vehicles. These standards will continue to operate side by side with this BS AU 178 for the time being.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

1. Scope

This British Standard specifies requirements for safety glass for installation either as windscreens or as other windows or as partitions in motor vehicles and trailers (see 3.1 and 3.2).

2. References

The titles of the publications referred to in this standard are listed below.

British Standards

BS 857* Safety glass for land transport

BS 5282* Road vehicle safety glass

International standards

ISO 3537-1975 Road vehicles — Safety glasses — Test methods for mechanical properties

ISO 3538-1975 Road vehicles — Safety glasses — Test methods for optical properties

ISO 3917-1976 Road vehicles — Safety glasses — Test methods for resistance to radiation, high temperature, humidity and fire

European Economic Community: EEC Directives

EEC Directive 78/317/EEC — Defrosting and demisting systems of glazed surfaces of motor vehicles

EEC Directive 77/649/EEC — Field of vision of motor vehicle drivers

International Commission on Illumination (CIE) Publications

Publication CIE No. 15 (E-1.3.1) 1971 — Colorimetry — Official recommendations of the International Commission on Illumination

Proceedings of the 1931 meeting of the International Commission on Illumination (CIE)

3. Definitions

For the purposes of this British Standard the following definitions apply.

3.1 motor vehicle. A mechanically propelled vehicle intended or adapted for use on roads (Road Traffic Act 1972).

3.1.1 M₁ vehicle. A vehicle used for the carriage of passengers and comprising no more than 8 seats in addition to the driver's seat.

NOTE. A list of EEC and ECE vehicle categories with definitions is given for information in appendix K.

3.2 trailer. A vehicle drawn by a motor vehicle (Road Traffic Act 1972).

3.3 slow moving vehicle. An industrial or agricultural tractor capable of a speed not exceeding 30 km/h on level ground.

3.4 toughened glass. A glass consisting of a single layer that has been subjected to special treatment to increase its mechanical strength and to condition fragmentation after shattering.

3.5 laminated glass. A glass consisting of two or more layers held together by one or more interlayers of plastics material. Laminated glass may be either ordinary (see 3.5.1) or treated (see 3.5.2).

3.5.1 ordinary laminated glass. Laminated glass in which none of the layers of glass of which it is composed has been treated.

3.5.2 treated laminated glass. Laminated glass in which at least one of the layers of glass of which it is composed has been specially treated to increase the mechanical strength and to condition fragmentation after shattering.

3.6 group of windscreens. Windscreens of different sizes and shapes that can be considered to have the same characteristics for mechanical properties, fragmentation and resistance to the environment tests.

3.6.1 flat windscreen. A windscreen with no curvature.

3.6.2 curved windscreen. A windscreen that is curved in at least one direction.

3.7 principal characteristic. A characteristic that substantially changes the optical and/or mechanical properties of a safety glass with regard to its application to a vehicle. The trade name or mark of the manufacturer is also a principal characteristic (see 4.2).

3.8 secondary characteristic. A characteristic that significantly but not substantially changes the optical and/or mechanical properties of a safety glass with regard to its application to a vehicle. The significance of the change is judged in relation to the indices of difficulty (see 4.3).

3.9 indices of difficulty. A two-stage grading applying to the variation in practice of each secondary characteristic. Table 1 shows the characteristics to which the indices relate; a change from index (1) to index (2) requires additional testing.

3.10 developed area of a windscreen. The minimum rectangular area of glass from which a windscreen can be developed.

3.11 inclination angle of a windscreen. The angle included between a vertical line and the straight line passing through the top and bottom edges of the windscreen, these lines being defined in a vertical plane containing the longitudinal axis of the vehicle.

NOTE 1. The measurement of the inclination angle is based on a vehicle standing on level ground; the vehicle is in running order, complete with fuel, coolant, lubricant, tools and spare wheel (if

*Referred to in the foreword only.

provided as standard equipment by the vehicle manufacturer) including the mass of a driver and, in the case of passenger cars, of one front seat passenger (taking $75 \pm 0, - 1$ kg per passenger).

NOTE 2. Vehicles equipped with hydropneumatic, hydraulic or pneumatic suspension or a device for automatic levelling according to load should be tested in the normal running condition specified by the manufacturer.

3.12 height of segment. The maximum dimension to the inner surface of the glass from a plane contacting the glass extremities, measured approximately normal to the glass (see figure 1).

3.13 minimum radius of curvature. The approximate value of the smallest radius of windscreen arc measured in the most curved area of the windscreen.

3.14 type of safety glass. Safety glass, as defined in 3.4 and 3.5, not exhibiting any essential differences of a kind relating, in particular, to the principal and secondary characteristics listed in clause 4.

3.15 secondary image. A spurious or ghost image, usually seen at night when the object being viewed is very bright in relation to its surroundings, e.g. the headlights of an approaching vehicle.

3.16 sample. A safety glass product, selected as representative of a production batch, and submitted for test.

3.17 test piece. An article, subjected to a test procedure, which may either be specially prepared for the purpose or cut from a sample; in appropriate cases a complete safety glass product may serve as a test piece.

3.18 daylight opening. The clear and unobstructed aperture in the body of a vehicle into which a safety glass is fitted.

4. Glazing characteristics

4.1 General. A safety glass product is defined by its principal and secondary characteristics. (See 4.2 and 4.3 for a complete list applying to all safety glass products.)

Although a change in principal characteristics implies a new type of product, 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 as prescribed in the appendices glasses may be grouped if it is evident that they have similar principal characteristics.

Specimens of glass exhibiting differences only as regards the secondary characteristics referred to in 4.3 may be considered as of the same type; certain tests may, however, be carried out on samples of such glass, if such tests are explicitly stipulated in the test conditions.

4.2 Principal characteristics. The principal characteristics referred to in 3.7 shall be as follows:

- (a) the trade name or mark of the manufacturer;
- (b) the shape and dimensions (length, width, height of segment and minimum radius of curvature) in the case of windscreens, and the category of shape (flat or curved) in the case of toughened windows other than windscreens;
- (c) the number of layers of glass;
- (d) the nominal thickness, e , in the case of windscreens, or category of thickness in the case of windows other than windscreens;
- (e) the nominal thickness and the nature (foil or airgap) and the type of the interlayer(s), e.g. polyvinyl butyrate (PVB) or other plastics interlayer(s);

- (f) the nature of the toughening (thermal or chemical);
- (g) the special treatment of laminated glass.

4.3 Secondary characteristics (see table 1). The secondary characteristics referred to in 3.8 shall be as follows:

- (a) the nature of the glass (plate, float or sheet);
- (b) the colouring of the interlayer(s) (colourless or tinted);
- (c) the colouring of the glass (colourless or tinted);
- (d) the incorporation of electrical conductors;
- (e) the incorporation of obscuration bands.

5. General requirements and application

5.1 All glass, including windscreen glass, shall be such that, in the event of shattering, the danger of personal injury is reduced to a minimum.

The glass shall be sufficiently resistant to conditions to be expected in normal traffic, and to atmospheric and heat conditions, chemical action and abrasion.

5.2 Windscreens shall, in addition, be sufficiently transparent, and not cause any noticeable distortions of objects seen through the windscreen or cause any confusion between the signalling colours normally used. In the event of the windscreen shattering, the driver shall still be able to see the road clearly so that he can brake and stop his vehicle safely.

5.3 The thicknesses of glass generally available in the United Kingdom for use in the automobile industry are given for information in appendix H.

5.4 Safety glass application

5.4.1 The windscreens of slow moving vehicles shall be of zone toughened glass, uniformly toughened glass or high performance laminated glass.

5.4.2 The windscreen of M_1 and vehicle categories other than slow moving vehicles, shall be either of zone toughened glass or high performance laminated glass.

5.4.3 The windows, other than windscreens, of all categories of vehicle, shall be of high performance or standard laminated glass, or uniformly toughened glass.

6. Particular requirements

6.1 General requirements. All types of safety glass shall comply with the general requirements described in appendix A. Depending on the category to which they belong, they shall, in addition, comply with the particular requirements stated in 6.2.1 to 6.2.7.

NOTE. Tests need only be performed if the test authority requires them, having regard to the information already in its possession on the product and the materials used.

6.2 Particular requirements

6.2.1 For toughened glass windscreens, the requirements are specified in appendix B.

6.2.2 For uniformly toughened glass windscreens in slow moving vehicles, the requirements are specified in appendix C, the headform test is specified in B.6 and the optical requirements are specified in A.8.

6.2.3 For toughened glass windows other than windscreens, the requirements are specified in appendix C.

6.2.4 For ordinary laminated glass windscreens, the requirements are specified in appendix D.

6.2.5 For ordinary laminated glass windows other than windscreens, the requirements are specified in appendix E.

6.2.6 For treated laminated glass windscreens, the requirements are specified in appendix F.

6.2.7 For plastics-coated laminated glass windscreens, the requirements are specified in appendix L.

7. Purpose of the tests

7.1 The following tests are specified in this British Standard.

7.1.1 Fragmentation. The purpose of this test is to:

- (a) verify that the fragments and splinters produced after fracture are such as to minimize the risk of injury; and
- (b) verify the transparency of windscreens after shattering.

7.1.2 Mechanical strength

7.1.2.1 Ball impact test. There are two forms of test, one using a 227 g ball and one using a 2.26 kg ball, as stated in 7.1.2.1.1 and 7.1.2.1.2.

7.1.2.1.1 227 g ball test. The purpose of this test is to assess the adhesion of the interlayer in laminated glass, and the mechanical strength of toughened glass other than windscreens.

7.1.2.1.2 2.26 kg ball test. The purpose of this test is to assess the penetration resistance of laminated glass.

7.1.2.2 Head form test. The purpose of this test is to verify compliance with requirements relating to the limitation of injury in the event of impact against laminated glass other than windscreens, or the windscreen or double windows, and double-glazed units for use in side windows of buses or coaches.

7.1.3 Resistance to the environment

7.1.3.1 Abrasion test. The purpose of this test is to determine that the resistance to abrasion of a safety glass exceeds a specified value.

7.1.3.2 High temperature test. The purpose of this test is to verify that, when exposed to high temperatures over an extended period of time, no bubbles or other defects occur in laminated glass.

7.1.3.3 Resistance to radiation test. The purpose of this test is to determine whether the light transmittance of laminated glass, when exposed to radiation over an extended

period of time, is significantly reduced or whether the material is significantly discoloured.

7.1.3.4 Humidity test. The purpose of this test is to determine whether a laminated glass will withstand the effect of humidity in the atmosphere over an extended period of time without significant defects.

7.1.4 Optical qualities

7.1.4.1 Light transmission test. The purpose of this test is to determine whether the regular transmittance of light through safety glass exceeds a specified value.

7.1.4.2 Optical distortion test. The purpose of this test is to verify that objects viewed through a windscreen are not distorted to an extent likely to confuse the driver.

7.1.4.3 Secondary image separation test. The purpose of this test is to verify that the angular separation of the secondary image from the primary image does not exceed a specified value.

7.1.4.4 Identification of colours test. The purpose of this test is to verify that a windscreen does not cause confusion of colours seen through it.

8. Detailed schedule of tests for safety glass

8.1 Safety glass shall be subjected to the tests given in table 2.

8.2 A safety glass product shall be deemed to comply with the requirements of this British Standard if all the requirements specified in the appropriate clauses indicated in table 2 have been satisfied.

9. Application for approval and procedure on any subsequent modification of the product

The procedure for applying for approval of a category of glass, and the information it is necessary to provide with the application, are included in appendix J. The procedure to be followed in the event of subsequent modification of the safety glass or group of windscreens for which approval was originally granted is also described in appendix J.

10. Marking

10.1 General. Identification marks on safety glass, complying with the requirements of 10.2, 10.3 or 10.4 as appropriate, shall be arranged in close proximity to each other and to any relevant approval mark.

Table 1. Secondary characteristics (showing indices of difficulty (1) and (2) where appropriate)

1	2	3	4	5	6
Test prescribed	Windscreens			Windows other than windscreens	
	Toughened	Ordinary laminated and plastics-coated laminated	Treated laminated	Toughened	Laminated
Fragmentation*	Nature of material*†† Float and sheet identical — separate approval for plate	No test	As for toughened windscreens*	As for toughened windscreens*	No test
Mechanical strength	No tests	Secondary characteristics not involved	As for ordinary laminated windscreens	Float or sheet (1) Plate (2)	As for ordinary laminated windscreens
				Clear (1) Tinted (2)	
Behaviour under impact of the head	Secondary characteristics not involved	Secondary characteristics not involved	As for ordinary laminated windscreens	As for toughened windscreens§	As for ordinary laminated windscreens
High temperature	No test	Clear interlayer (1) Tinted interlayer (2)	As for ordinary laminated windscreens	No test	As for ordinary laminated windscreens
Resistance to radiation	No test	Clear interlayer (1) Tinted interlayer (2)	As for ordinary laminated windscreens	No test	As for ordinary laminated windscreens
		Tinted glass (1) Clear glass (2)			
Light transmission	Clear (1) Tinted (2)	Clear interlayer (1) Tinted interlayer (2)	As for ordinary laminated windscreens	Clear (1) Tinted (2)	As for ordinary laminated windscreens
		Clear glass (1) Tinted glass (2)			
Optical distortion	Plate and float (1) Sheet (2)	Plate and float (1) Sheet (2)	As for ordinary laminated windscreens	¶	**
	Type of vehicle†	Type of vehicle†			
Secondary image	Plate and float (1) Sheet (2)	Plate and float (1) Sheet (2)	As for ordinary laminated windscreens	¶	**
	Type of vehicle	Type of vehicle			
Identification of colours	Each type of tint	Each type of tint	As for ordinary laminated windscreens		**
Abrasion test‡	No test	Dependent on material	Dependent on material	No test	Dependent on material
Humidity	No test	Clear interlayer (1) Tinted interlayer (2)	As for ordinary laminated windscreens	No test	Clear interlayer (1) Tinted interlayer (2)

*Where a change is made from float or sheet glass to plate glass, or vice versa, the fragmentation tests shall be repeated.

†When considering a group of windscreens, representative windscreens shall be chosen for test that have the greatest rate of change of curvature and are intended for mounting at the greatest rake angle.

‡The abrasion test may be carried out when the material forming the outer surface of the windscreen is changed.

§ Test required for double-glazed units only.

|| Shade and/or obscuration bands, (1) not included; (2) included.

¶ As for toughened windscreens if C.13 is applicable.

**As for ordinary laminated windscreens if E.6 is applicable.

††Shade or obscuration bands other than painted.

Table 2. Tests specified for the categories of glass defined in 3.4 and 3.5

Test	Windscreens				Other than windscreens	
	Zone toughened	Uniformly toughened	Ordinary+ laminated	Treated laminated	Toughened	Laminated
Fragmentation test	B.3	C.2	—	F.1	C.2	—
Ball impact test for mechanical strength	227 g	C.7	D.5.2	D.5.2	C.7.1	E.4
	2.26 kg	—	D.5.1	D.3.1	—	—
Head form test (samples)	B.6.1.1	B.6.1.1	D.3	D.3	*C.9	—
	or	or				
Head form test (test pieces)	B.6.1.2	B.6.1.2	D.4	D.4	—	E.3
Abrasion test	—	—	A.4	A.4	—	A.4
High temperature test	—	—	A.5	A.5	—	A.5
Resistance to radiation test	—	—	A.6	A.6	—	A.6
Humidity test	—	—	A.7	A.7	—	A.7
Light transmission test	A.8.1	A.8.1	A.8.1	A.8.1	A.8.1†	A.8.1†
Optical distortion test	A.8.3	A.8.3	A.8.3	A.8.3		
Secondary image test	A.8.6	A.8.6	A.8.6	A.8.6		
Identification of colours test	A.8.9	A.8.9	A.8.9	A.8.9		

*In the case of double-glazed units only.

†The provisions concerning optical qualities in A.8 shall apply to windows that are necessary to comply with any requirements concerning the driver's field of view in all directions.

‡Plastics-coated laminated glass windscreens shall, in addition to the test given in this column, be subjected to the tests specified in appendix L.

10.2 Marking on toughened safety glass. The following particulars shall be indelibly and distinctly marked by the manufacturer on every piece of toughened safety glass accepted for glazing in a land vehicle:

- (a) the name, registered trademark or BS licence number of the manufacturer;
- (b) in the case of uniformly heat toughened glass, the letter 'T' or the word 'tempered' or 'toughened';
- (c) in the case of a zone toughened windscreen, the letters 'WT';
- (d) in the case of a uniformly toughened safety glass windscreen for a slow moving vehicle, the letter 'W';
- (e) the number of this British Standard, i.e. BS AU 178*.
- (f) a mark identifying the date, at least to the nearest month, and the site of manufacture.

NOTE. It is strongly recommended that, in the case of asymmetrical windscreens, there should be an adhesive label on the windscreen indicating whether it is intended for a left-hand drive or right-hand drive vehicle.

10.3 Marking on laminated safety glass. The following particulars shall be indelibly and distinctly marked by the manufacturer (except as indicated in 10.4) on every piece of laminated safety glass accepted for glazing in a land vehicle:

- (a) the name, registered trademark or BS licence number of the manufacturer;

(b) in the case of a non-windscreen glass, the word 'laminated' or the letter 'L';

(c) in the case of a windscreen, the words 'laminated windscreen' or the letters 'WL';

(d) in the case of a treated laminated windscreen, the words 'treated laminated windscreen' or the letters 'WLT';

(e) the number of this British Standard, i.e. BS AU 178*.

(f) a mark identifying the date, at least to the nearest month, and the site of manufacture.

10.4 Marking on laminated safety glass cut from stock sizes.

In the case of laminated glass sheets in stock sizes that are supplied for cutting and fitting by stockists, the requirements of 10.4.1 to 10.4.3 shall apply.

10.4.1 The manufacturer shall apply to each sheet the appropriate markings as specified in 10.3.

10.4.2 The stockist, by agreement and arrangement with the manufacturer, shall ensure that every piece of glass cut from a stock size shall be indelibly and distinctly marked with the appropriate markings as specified in 10.3.

10.4.3 In addition, the stockist shall mark on every piece of glass cut from a stock size a means of identification of the stockist, details of which shall be supplied to the manufacturer concerned.

*Marking BS AU 178 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification to support such claims should be addressed to the Director, British Standards Institution, 389 Chiswick Avenue, Hemel Hempstead, Herts HP2 4SQ in the case of certification marks administered by BSI or to the appropriate authority for other certification marks.

Appendix A

General test conditions

A.1 Fragmentation test

A.1.1 Test method

A.1.1.1 The test piece shall not be clamped; it may, however, be fastened to an identical piece of glass by adhesive tape all round the edge.

A.1.1.2 To obtain fragmentation, a hammer of approximately 75 g or other appliance giving equivalent results shall be used. The radius of curvature of the point shall be 0.2 ± 0.05 mm.

A.1.1.3 One test shall be carried out at each of the prescribed points of impact (see figures 2 and 3).

A.1.1.4 A record shall be made of the fragments on contact photographic paper, exposure commencing not more than 10 s after impact and terminating not more than 3 min after impact. Only the darkest lines, representing the initial fracture, shall be taken into consideration. The laboratory shall retain the photographs of the fragmentation obtained.

A.1.2 Interpretation of results. See B.5, C.6 and F.4.4.

A.2 Ball impact test for mechanical strength

A.2.1 Test method

A.2.1.1 The test shall be carried out by means of a solid, hardened steel ball falling freely from a specified height, or given a velocity equivalent to that obtained by the free fall. The mass of the ball shall be defined for the different types of safety glass and the ball shall fall within 25 mm of the centre of the test piece.

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

A.2.1.2 When the ball falls freely, it shall be released without any impetus being given to it (e.g. by using an electromagnet).

A.2.2 Supports for test pieces

A.2.2.1 The test piece shall be mounted on a support (see figure 4) consisting of two steel frames, with machined edges 15 mm wide, fitting one over the other and faced with rubber gaskets approximately 3 mm thick and 15 mm wide, of hardness 50 IRHD (Shore hardness A.50).

A.2.2.2 The lower frame shall rest on a steel box about 150 mm high.

A.2.2.3 The test piece shall be held in place by the upper frame which shall have a mass of about 3 kg. The apparatus shall be welded onto a sheet of steel 12 mm thick resting on a sheet of rubber of hardness 50 IRHD and about 3 mm thick, placed on a rigid base, e.g. a substantial concrete base.

A.2.3 Test conditions. The test shall be carried out under the following conditions:

Temperature:	20 ± 5 °C
Pressure:	860 mbar to 1060 mbar*
Relative humidity:	60 ± 20 %

A.2.4 Test method. The method shall be in accordance with the test method specified in clause 5 or clause 6 of ISO 3537-1975, as appropriate.

A.2.5 Interpretation of results. See C.8, D.5.1.3, D.5.2.3 and E.4.3.

A.3 Head form test

A.3.1 Apparatus

A.3.1.1 Support for samples. (See figure 5.)

A.3.1.1.1 The sample shall rest freely on a strip of rubber, of hardness 70 IRHD and about 3 mm thick, placed on a support, the width of contact all round the perimeter being about 15 mm.

A.3.1.1.2 The support shall consist of a rigid piece of softwood of minimum thickness 75 mm conforming to the shape of the sample, and shall be arranged in such a way that the head form described in A.3.1.3 strikes the inside of the windscreen at its centre in the course of the test.

A.3.1.1.3 The support shall rest on a sheet of rubber, of hardness 70 IRHD and about 3 mm thick, placed on a rigid base, e.g. a substantial concrete base.

A.3.1.2 Support for test pieces

A.3.1.2.1 The test piece shall be clamped in the test frame shown in figure 6, by means of at least eight bolts.

A.3.1.2.2 The fixture is composed of two steel frames, with machined edges, 50 mm wide, fitting one over the other and faced with rubber gaskets about 3 mm thick and 15 ± 1 mm wide of hardness 70 IRHD.

A.3.1.2.3 The test frame shall be placed on a rigid base, e.g. a substantial concrete base.

A.3.1.3 Head form

A.3.1.3.1 The head form (see figure 7) shall consist of the following elements:

(a) A solid spherical or semi-spherical head made of laminated hardwood of diameter 190 ± 2 mm. The lower hemisphere of the head shall be covered with replaceable felt about 5 mm thick.

(b) A mounting rod between 500 mm and 1000 mm long and weighing less than 0.5 kg.

A.3.1.3.2 The head form may also incorporate the following elements:

(a) a rigid intermediate piece of hardwood 70 mm long and 100 mm in diameter;

(b) a cross beam made of wood and representing the shoulders, about 500 mm long and about 100 mm wide. The thickness of this cross beam shall be such that the total mass of the head form shall be 10 ± 0.2 kg.

A.3.1.3.3 Means for dropping the head form freely from a height shall be specified, or a means for giving it 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 ± 1 % of the velocity equivalent to that obtained by the free fall.

A.3.2 Test conditions

Temperature:	20 ± 5 °C
Pressure:	860 mbar to 1060 mbar
Relative humidity:	60 ± 20 %

*1 mbar = 10^2 N/m² = 100 Pa.

A.3.3 Test method. The method shall be in accordance with the test method specified in 9.3 of ISO 3537-1975.

A.3.4 Interpretation of results. See B.6.3, D.3.3, E.3.3 and F.4.4.

A.4 Abrasion resistance test

A.4.1 Apparatus. The following apparatus is required.

A.4.1.1 Abrading instrument*, shown diagrammatically in figure 8, and consisting of the following:

a horizontal turntable and centre clamp which revolves counter-clockwise at 65 r/min to 75 r/min;

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

The turntable of the abrading instrument shall rotate regularly and substantially in one plane. The deviation from this plane shall be not greater than 0.05 mm at a distance of 1.6 mm from the turntable periphery.

The wheels shall be mounted in such a way that, when they are in contact with the rotating test specimen, they rotate in contrary directions so as to exert a compressive and abrasive action along curved lines over an annular area of about 300 mm², twice during each rotation of the test specimen.

A.4.1.2 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. The wheels shall have an IRHD hardness of 72 ± 5 , measured at four points equally spaced on the centre line of the abrading surface with the pressure applied vertically along a diameter of the wheel, the readings being taken 10 s after full application of the pressure.

The abrasive wheels shall be prepared for use by very slow rotation against a sheet of flat glass.

A.4.1.3 Light source, consisting of an incandescent lamp, the filament of which is contained within a parallelepiped 1.5 mm x 1.5 mm x 3 mm. The voltage at the lamp terminals shall be such that the colour temperature is 2856 ± 50 K. This voltage shall be stabilized within ± 1 %. The instrument used to check the voltage shall be of appropriate accuracy.

A.4.1.4 Optical system, consisting of a lens with a focal length of at least 500 mm and corrected for chromatic aberrations. The clear aperture of the lens shall be adjusted in order to obtain a light beam that is substantially parallel.

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.

A.4.1.5 Equipment for measuring scattered light (haze-meter) (see figure 9), consisting of a photoelectric cell with an integrating sphere of diameter of 200 mm to 250 mm. The sphere shall be equipped with entrance and exit ports for the light. The entrance port shall be circular and have a diameter at least twice that of the light beam. The exit port of the sphere shall be provided with a light trap and with a reflectance standard. The light trap shall absorb all the light when no test specimen is inserted in the light beam.

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 $2a \tan 4^\circ$, where a is the diameter of the sphere. The photoelectric cell shall be mounted in such a way that it cannot be reached by light coming directly from the entrance port or from the reflectance standard.

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

The output of the photoelectric cell shall be linear within 2 % over the range of luminous intensity used. The design of the instrument shall be such that there is no galvanometer deflection when the sphere is dark. The whole apparatus should be checked at regular intervals by means of calibration standards of defined haze.

If haze measurements are made using equipment or methods differing from the above, the results shall be corrected in order to be in agreement with those obtained by the apparatus described.

A.4.2 Test pieces. The test pieces shall be flat squares of side 100 mm having both surfaces substantially plane and parallel, and with a 6.5 ± 0.1 mm diameter hole drilled in the centre.

A.4.3 Preparation of test pieces

A.4.3.1 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 demineralized water.
- (c) Blow dry with oxygen or nitrogen.
- (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 shall be avoided.

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.

A.4.3.2 Condition the test specimens prior to testing for a minimum time of 48 h at $20 \pm 5^\circ\text{C}$ and 50 ± 2 % relative humidity.

*A suitable abrading instrument is supplied by Teledyne Taber (USA) from whom abrasive wheels may also be obtained.

A.4.4 Test method

A.4.4.1 Immediately after completion of the conditioning period place the test piece against the entrance port of the integrating sphere. The angle between the normal to the surface of the test piece and the axis of the beam shall not exceed 8°.

Take four readings as indicated in table 3.

Table 3. Readings required for abrasion resistance test

Reading	With specimen	With light trap	With reflectance standard	Quantity represented
T_1	No	No	Yes	Incident light
T_2	Yes	No	Yes	Total light transmitted by test specimen
T_3	No	Yes	No	Light scattered by instrument
T_4	Yes	Yes	No	Light scattered by instrument and test piece

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

A.4.4.2 Determine the initial haze of the test specimen at a minimum of four equally spaced points in the unabraded area in accordance with the formula in A.4.5.1.

Average the results for each test specimen. As an alternative to making four separate measurements an average value may be obtained by rotating the test piece uniformly at 3 r/s or more.

A.4.4.3 For each type of safety glass, carry out three tests with the same load on the side representing the outer surface of the glass. Use the haze as a measure of the surface abrasion after the test-piece has been subjected to abrasion for 1000 cycles.

A.4.4.4 Determine the light scattered in the abraded track at a minimum of four equally spaced points along the track in accordance with the formula in A.4.5.1. Average the results for each test piece. As an alternative to making four separate measurements an average value may be obtained by rotating the test piece uniformly at 3 r/s or more.

A.4.5 Calculation and interpretation of results

A.4.5.1 Calculate the total transmittance $T_t = T_2/T_1$.

Calculate the diffuse transmittance T_d as follows:

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

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

$$\text{Haze or light scattered, or both} = \frac{T_d}{T_t} \times 100 \%$$

A.4.5.2 Subtract the average initial haze from the average total light scattered, the difference representing the light

scattered as a result of abrading the test piece. Calculate this difference for the surface abrasion.

A.4.5.3 Safety glass shall be considered satisfactory from the point of view of abrasion resistance if the light scattered as a result of abrading the test piece does not exceed 2%.

A.5 High temperature test

A.5.1 Test method

A.5.1.1 The test pieces shall be immersed vertically for 3 min in water at approximately 66°C, then plunged rapidly in the same way into boiling water and kept there for 2 h.

A.5.1.2 If the test is carried out on a test piece cut from a windscreen, the surface area shall be not less than 300 mm x 300 mm, bounded on one side by the upper edge of the windscreen.

A.5.2 Interpretation of results

A.5.2.1 The test shall be deemed to have given a positive result if bubbles or other defects are not formed more than 15 mm from the outer edge of the test piece or more than 10 mm from any cracks which may occur during the test.

A.5.2.2 No account shall be taken of bubbles or defects within 25 mm of the cut edge of a test piece cut from a windscreen.

A.5.2.3 A set of test pieces submitted for approval shall be considered satisfactory as regards the high temperature test if either of the conditions given in (a) or (b) is fulfilled.

(a) All the tests give a positive result.

(b) One test having given a negative result, a further series of tests carried out on a new set of test pieces all give positive results.

A.6 Resistance to radiation test

A.6.1 Test method

A.6.1.1 Each test piece or sample (total number three pieces) shall be submitted to radiation in accordance with the procedure specified in clause 5 of ISO 3917-1976, such that the radiation on each point of the test piece or sample produces, on the interlayer used, the same effect as that which would be produced by a solar radiation of 1400 W/m² for 100 h.

A.6.1.2 Maintain the temperature of the test pieces at 45 ± 5°C throughout the test.

A.6.2 Interpretation of results

A.6.2.1 The test for resistance to radiation shall be deemed to have given a positive result if the conditions in (a) and (b) are fulfilled:

(a) the total luminous transmittance does not fall below 95 % of the original value before irradiation, or below 70 %, the transmittance being measured in accordance with clause 5 of ISO 3538-1975;

(b) if the test is carried out on a test piece cut from or representing a windscreen, the total transmittance remains greater than 75 % in the zone where the regular transmittance is to be checked, as defined in A.8.1.7.

A.6.2.2 The test piece may show a slight coloration after irradiation when examined against a white background, but no other defect shall be apparent.

A.6.2.3 A set of test pieces submitted for approval shall be considered satisfactory from the point of view of stability if either of the following conditions is fulfilled:

- (a) all the tests give a positive result; or
- (b) one test having given a negative result, a further series of tests carried out on a new set of test pieces all give positive results.

A.7 Humidity test

A.7.1 Test method

A.7.1.1 Three test pieces of at least 300 mm x 300 mm shall be kept vertically for two weeks in a closed container in which the temperature is maintained at $50 \pm 2^\circ\text{C}$, and the relative humidity at $95 \pm 4\%$.

A.7.1.2 If several test pieces are tested at the same time, adequate spacing should be provided between them.

A.7.1.3 Means shall be provided to prevent condensate from the walls and ceiling of the container falling on the specimens.

A.7.1.4 If the test pieces are cut from windscreens one edge of the test piece shall be part of the outer edge of the windscreen.

A.7.2 Interpretation of results

A.7.2.1 The resistance to humidity is evaluated visually by reference to changes in appearance of a safety glass after testing, i.e. a separation of materials and/or a loss of transparency.

A.7.2.2 No assessment shall be made within 10 mm of uncut edges or within 15 mm of cut edges.

A.7.2.3 Laminated safety glass shall be deemed to be satisfactory from the point of view of resistance to humidity if no significant change is observed.

A.7.2.4 If one test piece gives an unsatisfactory result the test shall be repeated on a new set of three test pieces and all shall give a satisfactory result for the glass to be deemed satisfactory.

A.8 Tests for optical qualities

A.8.1 Light transmission test

A.8.1.1 The regular transmission factor, t , is obtained by dividing the light flux as modified by the glass, F_R , by the incident light flux, F_o therefore

$$t = \frac{F_R}{F_o}$$

A.8.1.2 The source of radiation shall be an incandescent lamp of colour temperature $2856 \pm 50\text{ K}$ representing illuminant A* of the International Commission on Illumination (CIE).

A.8.1.3 The receiver shall have a relative spectral sensitivity in substantial agreement with the relative spectral luminous efficiency of the CIE 1931† standard photometric observer for photopic vision.

A.8.1.4 The angle of incidence of the incident light beam shall be zero.

A.8.1.5 The section of the light beam through the windscreen shall be within the limits of a 20 mm square.

A.8.1.6 In the case of windscreens, either a test piece cut from the flattest part of a sample windscreen or a specially prepared flat square with identical material and thickness characteristics to the actual windscreen, and with the measurement taken normal to the glass, may be used.

A.8.1.7 For the windscreens of M_1 vehicles, the test shall be carried out in zone B specified in the EEC Directive concerning windscreen defrosting and demisting systems (78/317/EEC) (see figure 13). For all other vehicles, the test shall be carried out in zone I specified in A.8.4.2. (See figure 11.)

A.8.1.8 Test method. The method shall be in accordance with that described in clause 5 of ISO 3538-1978.

A.8.2 Interpretation of results. The regular transmittance measured according to A.8.1, in the case of windscreens, shall be not less than 75 % and, in the case of windows other than windscreens, shall be not less than 70 %. Exceptions are made for shade and obscuration bands and glazing for special applications, e.g. ambulance passenger compartment glazing.

A.8.3 Optical distortion

A.8.3.1 The optical distortion at a point M on the inner surfaces of the windscreen (see figure 10) is denoted by the symbol $\Delta\alpha$, the difference in the angular deviation measured at two points M and M', the distance between these two points being such that their projections onto a plane at right angles to the direction of measurement are separated by 4 mm.

A.8.3.2 Method. The method shall be in accordance with the test method described in clause 7 of ISO 3538-1978.

A.8.3.3 The windscreen shall be mounted at the angle of inclination corresponding to that on the vehicle.

A.8.3.4 The projection axis in the horizontal plane shall be maintained approximately normal to the glass in that plane.

A.8.3.5 For vehicle category M_1 , tests shall be carried out on the one hand in zone A, prolonged to the median plane of the vehicle, and on the part of the windscreen corresponding to the symmetry of the preceding zone with regard to the longitudinal median plane of the vehicle and, on the other hand, in zone B. For other categories of vehicles, the tests shall be carried out in zone I as defined in A.8.4.3.

A.8.3.6 Type of vehicle. The test shall be repeated if the windscreen is to be mounted on a vehicle of a type that has a different field of vision towards the front from that of the vehicle for which the windscreen has already been approved.

A.8.3.7 Number of samples. Four samples shall be submitted for testing.

A.8.4 Definitions of zones A, B and I

A.8.4.1 Zones A and B of the windscreen vehicle category M_1 are specified in document EEC Directive 78/317/EEC with the exception that zone A is extended to cover both sides of the windscreen as defined for zone B. (See figures 12 and 13.)

*As defined in Publication CIE No. 15 (E-1.3.1) 1971.

†As defined in the Proceedings of the 1931 meeting of the International Commission on Illumination (CIE).