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Specification for

Safety glass for land transport

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Co-operating organizations

The Glass Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following scientific and industrial organizations:

- British Glass Industry Research Association*
- Glass Manufacturers' Federation
- Society of Glass Technology*
- University of Sheffield (Department of Glass Technology)

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Automobile Association
- British Plastics Federation
- Chief Fire Officers' Association
- Flat Glass Manufacturers' Association
- Ministry of Technology
- Ministry of Transport
- Ministry of Transport — Road Research Laboratory
- Society of Motor Manufacturers and Traders Ltd.
- An individual manufacturer

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Foreword

This standard makes reference to the following British Standard:

BS 354, *Recommendations for photometric integrators*.

This British Standard was first published in 1939 and revised editions were published in 1949 and 1954. A major amendment to the 1954 edition was issued in 1961 when the zoned type of toughened glass windscreen was introduced. This was followed in 1964 by a separate publication of Parts 1 and 2 covering, for the first time, optical requirements for all windscreens and also a further revision of the toughened glass specification including both uniform and non-uniform wide-zone windscreens.

Minor editorial changes are not tagged, the amendments in this issue are described in the amendment table.

The representative technical committee which is responsible for this standard under the authority of the Glass Industry Standards Committee, continued its revision work on the laminated glass sections of the 1954 specification and in particular modified these to include a more severe impact test for windscreens, thus ensuring that only so-called "high performance" laminates will be used for this purpose. At the same time the impact requirements for all laminated glass have been made more stringent by increasing from 16 ft (4.9 m) to 30 ft (9.15 m) the height from which the ball is dropped in the fracture and adhesion test. A light stability test is included, in which the visual transmission of the laminate is measured both before and after exposure to ultraviolet radiation.

The toughened glass specification has also been reviewed in the light of technical advances made since 1964 and the following main changes are incorporated in the new edition.

- 1) Only zoned glass is now included for windscreens as it is felt that the uniformly toughened glass, which may obscure the driver's vision if it fractures, should no longer be used for windscreens.

NOTE By amendment in January 1973, the application of the above provision regarding zoned glass was limited to windscreens for the general run of road vehicles, and it was recognized that uniformly toughened glass is acceptable for the windscreens of railway locomotives and of relatively slow-moving agricultural and industrial tractors.

- 2) For purposes other than windscreens, provision has been made for the use of glass toughened by chemical treatment, instead of heat treatment, provided it meets the requirements of the standard.

- 3) The requirements for zoned windscreens have been made more stringent by defining the maximum size of individual particles after fracture and the test procedure for the non-uniform zone glass (Type Z2) has been modified so as to encourage the manufacture of windscreens which give better visibility in the event of fracture.

In keeping with the general changeover of the British industry to the metric system, dimensional requirements have been given in metric units throughout this revision, with the corresponding inch-lb units given also for information. The committee has studied the latest standards and proposals for safety glass in vehicles, prepared in the USA and on the continent of Europe, and where considered appropriate the specification requirements and test procedures of this standard have been harmonized with such overseas standards.

The testing equipment and procedure described in Appendix A to Appendix F are substantially unchanged from the earlier editions, except that Appendix F now covers the requirements of the more severe impact test referred to above. Data are also given in Appendix G, for information only, indicating the effect of windscreen design features (e.g. rake angle and designed curvature) on the optical characteristics.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 31 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

1 General clauses, and optical requirements for windscreens

1.1 Scope

This British Standard specifies requirements and tests for flat and curved safety glass for land transport, of thicknesses from 2 mm (0.08 in) to 13 mm (0.5 in).

1.2 Definitions and general requirements

For the purposes of this British Standard the following definitions apply. Mandatory general requirements, where applicable, are also given.

1.2.1

safety glass (general definition)

a glass which, if fractured, is less likely to cause severe cuts or serious physical injury than ordinary glass

1.2.2

safety glass for windscreens

a glass as defined above which in addition does not cause any appreciable distortion of objects ahead of the vehicle seen through it; and which, if fractured, permits a sufficient view ahead to enable the driver to control the vehicle whilst bringing it to rest

1.2.3

toughened safety glass (also known as tempered safety glass)

glass which has been converted to a safety glass by subjection to a process of pre-stressing so that, if fractured, it disintegrates into small pieces. In general, its liability to fracture under the action of external forces or changes of temperature is greatly reduced by this process. Unless otherwise specified the pre-stressing is substantially uniform over the whole area of the glass

pre-stressing may be carried out by heating and rapid cooling or by chemical treatment

1.2.4

heat-treated safety glass for windscreens

heat-treated safety glass having a zone of modified heat treatment in which the fragmentation, if the glass is fractured, comprises sufficient pieces of larger size than elsewhere to afford better vision through the zone than through the remainder of the glass

at least the marginal part of the glass, of a width not less than 6 cm (2.5 in) shall disintegrate upon fracture into small pieces. The dimensions and location of the zone shall be agreed between the vehicle maker and the manufacturer of the safety glass; even in the case of half-screens the dimensions of the zone shall be not less than 40 cm (16 in) × 15 cm (6 in)

three types of zoned windscreen are covered by this British Standard:

a) *Uniform small zone, Type Z*, in which the stresses in the glass are substantially even throughout a zone in front of the driver (see Figure 1A).

b) *Uniform wide zone, Type Z1*, in which the stresses in the glass are substantially even throughout a zone extending across the greater part of the windscreen (see Figure 1B).

c) *Non-uniform wide zone, Type Z2*, in which the stresses in the glass vary in intensity over the zone so that, if the glass is fractured, alternate areas break into fine and coarse particles respectively.

NOTE Uniformly toughened safety glass complying with the requirements of Section 2 of this standard is permitted for the windscreens of railway locomotives and of relatively slow-moving agricultural and industrial tractors capable of a speed not exceeding 20 mile/h (32.2 km/h) on level ground.

in general, the alternate areas shall be arranged in a regular pattern over the zone and the stresses in corresponding areas shall be substantially the same (see Figure 1C and Figure 1D)

1.2.5

laminated safety glass

a product made of two or more pieces of glass firmly united to, and alternating with, one or more pieces of reinforcing material (known as “interlayer” or “interleaf”). Fracture does not cause the glass to separate from the interlayer to any substantial extent and in general the product does not break into large fragments

1.2.6

primary vision area

that part of the windscreen through which the principal field of view is obtained (see Figure 2A and Figure 2B)

NOTE Figure 2A excludes from the primary vision area a band round the edge of the glass 6 cm (2.5 in) wide at top and bottom and 9 cm (3.5 in) wide at the sides. Compliance with the optical requirements in 1.3 implies the avoidance of sharp curvatures throughout the primary vision area.

1.2.7

consignment

the whole of the safety glass delivered at any one time in connection with an order or contract

Table 1 — Conditions of acceptance for windscreens (optical requirements)

	Conditions for passing group	Conditions for rejecting group	Conditions for retest	Conditions for passing group after retest	Conditions for rejecting group after retest
Number of specimens tested (for each shape)	5	5	5	10	10
Number of specimens satisfying requirements of 1.3.2 to 1.3.4	5	3 or less	4	9	8 or less

1.3 Optical requirements

1.3.1 General. The requirements detailed in 1.3.2 to 1.3.4 are specified only for windscreens and apply only to the primary vision area of the windscreen as defined in 1.2.1 6). Since this area necessarily varies, with different models of land transport vehicle according to the rake angle of the windscreen, seated height, distance from the windscreen and lateral placement of the driver, the vehicle manufacturer should define for each model the “eye position” to which the primary vision area is related¹⁾.

1.3.2 Optical deviation. When the windscreen is tested in accordance with Appendix A:

- 1) Using the “ring and spot” target, there shall be no displacement of the secondary image²⁾ 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.
- 2) 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.
- 3) There shall not be more than one secondary image.
- 4) From point to point in the test area there shall be no abrupt change in the displacement of the secondary image.

1.3.3 Distortion of vision. When the windscreen is tested in accordance with Appendix B:

- 1) It shall not cause breaks in the projected lines, easily seen by the un-aided eye.
- 2) Projected lines may be bowed relative to the lines on the screen provided that these projected lines do not overlap the lines on the screen. This is equivalent to a maximum primary deviation of ± 8.4 minutes of arc.

1.3.4 Visual transmission. When the windscreen is tested in accordance with Appendix C the visual transmission for light emitted by Standard Illuminant A shall be not less than 75 % for the primary vision area.

1.3.5 Acceptance requirements (see Table 1). If all the windscreens tested (see 2.5.2 and 3.4.3) satisfy the requirements of 1.3.2 to 1.3.4, the consignment shall be deemed to comply with this section of the standard. If one windscreen fails to satisfy these requirements, a further five windscreens of the same shape (and group if applicable) shall be tested and if all the windscreens in the second batch satisfy the requirements, the consignment shall be deemed to comply. If two or more windscreens of a given shape (and group if applicable) fail in the first test, or if one or more fail in the second test, all the windscreens of that shape (and group if applicable) in the consignment shall be deemed not to comply with this British Standard.

2 Requirements specific to toughened safety glass (including both heat-treated and chemically-treated glass)

2.1 Properties and quality

Toughened safety glass shall:

- 1) be transparent, translucent or coloured as required;
- 2) be free from faults which will interfere with vision, appearance³⁾ or service.

NOTE The production of small indentations in heat-treated safety glass within 13 mm (0.5 in) from the edge of the glass is a feature inherent in most processes at present used in the manufacture of a heat-treated safety glass. Such indentations are permissible, but any crack or vent from these indentations extending from the surface towards the interior of the glass, and/or any surface vent of length exceeding 1.6 mm (0.06 in), is contrary to the requirements of this standard.

¹⁾ Standard procedures are available for this purpose, as recommended by the Society of Motor Manufacturers and Traders Ltd. (UK) and the Automobile Manufacturers Association (USA).

²⁾ The secondary or “ghost” image is a spurious 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⁾ Standard of appearance to be agreed between the customer and the manufacturer.

- 3) have surfaces resistant to abrasion likely to be encountered in service and to the effects of exposure to the atmosphere;
- 4) be capable of withstanding normal treatment in the service for which it is supplied.

2.2 Thickness

2.2.1 The available nominal thicknesses of heat-treated safety glass are listed in Table 2 which also gives for information the approximate limits of these thicknesses. The thicknesses generally used in the automobile industry together with their approximate limits are listed for information in Table 3.

Table 2 — Limits of thickness for heat-treated safety glass

Nominal thickness	Limits of thickness	
	mm	in
$\frac{1}{8}$ in (including 3 mm, 24 oz and 26 oz)	2.75 to 3.5	0.108 to 0.138
$\frac{5}{32}$ in (including 4 mm and 32 oz)	3.8 to 4.8	0.150 to 0.189
$\frac{3}{16}$ in (including 5 mm)	4.8 to 5.5	0.189 to 0.217
$\frac{7}{32}$ in (including $\frac{1}{4}$ in bare)	5.15 to 6.35	0.203 to 0.250
$\frac{1}{4}$ in (including 6 mm)	5.6 to 7.1	0.221 to 0.280
$\frac{5}{16}$ in	6.75 to 7.93	0.266 to 0.312
$\frac{5}{16}$ in to $\frac{3}{8}$ in	7.93 to 9.52	0.312 to 0.375
$\frac{3}{8}$ in	9.12 to 10.32	0.359 to 0.407
$\frac{1}{2}$ in	11.9 to 13.5	0.468 to 0.532

Table 3 — Limits of thickness usual for heat-treated safety glass for the automobile industry

Nominal thickness	Limits of thickness	
	mm	in
Sheet glass:		
24 oz	2.75 to 3.05	0.108 to 0.120
26 oz	3.2 to 3.4	0.126 to 0.134
32 oz	3.8 to 4.2	0.150 to 0.165
$\frac{3}{16}$ in	4.8 to 5.2	0.189 to 0.205
Plate glass:		
$\frac{5}{32}$ in	3.8 to 4.3	0.150 to 0.169
$\frac{3}{16}$ in	4.8 to 5.2	0.189 to 0.205
$\frac{1}{4}$ in	6.0 to 6.4	0.236 to 0.252
Float glass:		
3 mm	2.8 to 3.2	0.110 to 0.126
4 mm	3.8 to 4.2	0.150 to 0.165
5 mm	4.8 to 5.2	0.189 to 0.205
6 mm	5.8 to 6.2	0.228 to 0.244

2.2.2 Chemically toughened glass is available within the range 1.8 mm to 2.5 mm (0.07 in to 0.10 in).

2.3 Marking

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

- 1) The name, registered trade mark or licence number of the manufacturer.
- 2) In the case of heat-treated toughened safety glass, the letter "T", or the word "Toughened", or the word "Tempered".
- 3) In the case of chemically toughened safety glass, the letters "CHT".
- 4) In the case of a heat-treated safety glass windscreen having a uniform small zone of modified heat-treatment of Type Z, the letter "Z".
- 5) In the case of a heat-treated safety glass windscreen having a uniform wide zone of modified heat-treatment of Type Z1, the symbol "Z1".
- 6) In the case of a heat-treated safety glass windscreen having a non-uniform wide zone of modified heat-treatment of Type Z2, the symbol "Z2".
- 7) In the case of a uniformly toughened safety glass windscreen [see Note to 1.2.4 c)], the letter "W".
- 8) In the case of toughened safety glass made from float glass, either the letter "F" or the word "Float".
- 9) In the case of toughened safety glass made from plate glass, either the letter "P" or the word "Plate".
- 10) In the case of toughened safety glass made from sheet glass, either the letter "S" or the word "Sheet".
- 11) An indication that the glass complies with the requirements of this British Standard. It is strongly recommended that in view of the nature of this specification, manufacturers and purchasers should make use of the scheme operated by the British Standards Institution (see below) whereby the product may bear the registered certification trade mark of the BSI. Alternatively, compliance shall be indicated by the use of the inscription "BS 857:1967".

12) Toughened glass windscreens complying with the requirements of this standard as amended by Amendment No. 1 (AMD 1088) and Amendment No. 2 (AMD 3402) shall be marked with the inscription "BS 857-2:1967".

NOTE The mark BS 857 on or in relation to the product is a claim by the manufacturer that it complies with the requirements of the standard.

The British Standards Institution is the owner of the registered certification trade mark shown below. This mark can be used only by manufacturers licensed under the certification mark scheme operated by the BSI. The presence of this mark on or in relation to a product is an assurance that the goods have been produced to comply with the requirements of the British Standard under a system of supervision, control and testing operated during manufacture and including periodical inspection at the manufacturer's works in accordance with the certification mark scheme of the BSI.

Further particulars of the terms of licence may be obtained from the Director, British Standards Institution, 2 Park Street, London, W.1.



2.4 Sampling and acceptance

Unless otherwise agreed, 5 %, but not less than five safety glasses, of the same nominal thickness, substantially equal in size and similar in shape, shall be taken at random from each consignment, grouped as described in 2.5.2 and tested for compliance with 1.3 (if applicable) and with 2.6.

If all the glasses tested of a group comply with all the requirements specified in 2.6.4 all the glasses in that group shall be deemed to comply with this section of the standard. If only one glass of a group fails to satisfy one or more of these requirements, five additional glasses shall be taken from the same group and tested for compliance with 2.6.4; if all the additional glasses satisfy all these requirements, all the glasses of that group shall be deemed to comply with this section of the standard. If in any group two or more of the original glasses, or one or more of the additional glasses, fail to satisfy one or more of these requirements, all the glasses of that group in the consignment shall be deemed not to comply with this British Standard.

2.5 Uniformity test

2.5.1 Apparatus. The apparatus shall be as described in Appendix D.

2.5.2 Procedure. All the glasses taken for test in accordance with 2.4 shall be illuminated by polarized light falling approximately normally on one face and examined from the opposite side through the analysing device. The whole area of each glass shall be examined and the glasses divided into groups having reasonably similar strain patterns⁴⁾. If any group contains less than five glasses, additional glasses shall be taken at random from the consignment until the group contains not less than five glasses. If new strain patterns are noted, sufficient glasses shall be taken at random from the consignment to obtain five glasses for each new strain group. If, after examining all the glasses, any group contains less than five, the glasses of this group shall be deemed not to comply with the requirements of this British Standard.

Five glasses from each group shall be taken for the optical test (1.3) (if applicable), followed by the fragmentation test (2.6). One of each set of five glasses shall be set aside as a standard of strain pattern and the four remaining glasses tested for fragmentation.

If the optical properties (if applicable) of any one of the five glasses proves to be unsatisfactory, five additional glasses of the same strain pattern group shall be taken from the consignment and the tests described in 1.3 shall be repeated.

If the fragmentation of any one of the four glasses proves to be unsatisfactory, four additional glasses of the same strain pattern group shall be taken from the consignment and the tests described in 2.6 shall be repeated.

If, in obtaining the additional glasses for the retest, further strain patterns are found, additional groups shall be formed. Each group of glasses shall be subjected to the optical test (if applicable) and the fragmentation test.

2.6 Fragmentation test

2.6.1 General. Notes on methods of supporting the specimens and of carrying out the particle count determination are given in Appendix E. The procedures for carrying out the test and interpreting the results are set out below and are summarized in Table 4 and Figure 3A to Figure 3D. Conditions for acceptance are set out in Table 5.

2.6.2 Procedure for test. Of each set of five glasses (see 2.5.2) four shall be supported as far as practicable over their whole area, means being provided to prevent any substantial spreading of the fragments (see Appendix E).

The four glasses shall be broken by means of a centre punch, the point of impact being:

- 1) In the case of a uniformly toughened safety glass, 13 mm (0.5 in) from the longest edge of the glass at the mid-point of that edge.
- 2) In the case of a small-zone heat-treated safety-glass windscreen or half-windscreen Type Z, on the longitudinal line passing through the centre of the vertical axis of the zone and 13 mm (0.5 in) from the intersection of that line with the end of the glass further from the zone.
- 3) In the case of a wide-zone heat-treated safety-glass windscreen of Type Z1 or Z2, in the centre of the zone.
- 4) In the case of a half-screen of Type Z1 or Z2, as near the centre of the zone as possible consistent with the requirements for the position of the first assessed area given in 2.6.3.5. In no case shall the point of impact be less than 7.5 cm (3 in) from the inner end of the zone.

2.6.3 Particle count and size determinations

2.6.3.1 All particle count determinations on any one piece of uniformly toughened glass shall be completed within 3 minutes of the fracture of that glass.

All particle count and size determinations on any one piece of glass that contains a zone of modified heat treatment shall be completed within 10 minutes of the fracture of that glass.

No magnifying lens or other aid to vision (except spectacles if normally worn) shall be used when making the particle counts described below.

2.6.3.2 When a uniformly toughened safety glass has been broken in accordance with 2.6.2 1), (see Figure 3A), the particles in a square of side 5 cm (2 in) shall be counted. The particle count shall be made in the region of coarsest fracture excluding the following regions:

- 1) A segment of radius 7.5 cm (3 in) centred on the point of impact.
- 2) Two further segments (S) of radius 7.5 cm (3 in) centred on the opposite edge, in the regions of coarsest fragmentation.

⁴⁾ Chemically toughened glass will show only a very slight pattern close to the edge of the glass. The major portion of the glass will be completely free from pattern.

If the count is between the limits stated in **2.6.4.1**, i.e. less than 60 but not less than 40 per 25 cm² (4 in²), a further particle count shall be made in an area of 100 cm² (16 in²) embracing the former area and the area of coarsest fracture adjacent. The counts shall be made in squares of side 5 cm (2 in) and 10 cm (4 in) respectively except that, in cases where such squares would encroach upon the periphery of the glass or any of the segments of radius 7.5 cm (3 in), the counts shall be made in rectangles of equivalent area.

A further count shall also be made in a square of side 5 cm (2 in) in the coarsest fragmentation area (S) defined in **2.6.3.2 2)** above.

2.6.3.3 When a small-zone heat-treated safety-glass windscreen of Type Z has broken in accordance with **2.6.2 2)**, (see Figure 3B), a count shall first be made of the particles in a square of side 10 cm (4 in) in the region of the coarsest fracture of the zone.

If the count in this square satisfies the requirements of **2.6.4.2** below:

- 1) A further count shall be made in a square of 5 cm (2 in) side in the region of the coarsest fracture of the glass outside the zone, excluding a segment of 7.5 cm (3 in) radius centred on the point of impact and extending to the margin, and two further segments (S) of radius 7.5 cm (3 in) centred one on each of the two long edges (if coarser particles occur in these regions).
- 2) The whole windscreen shall be examined for pointed or flanged long particles, and the number of such particles exceeding 7.5 cm (3 in) in length shall be noted.
- 3) The presence of any individual particle, of area exceeding 20 cm² (3 in²), shall also be noted.

2.6.3.4 When a wide-zone heat-treated safety-glass windscreen of Type Z1 or Z2 has been broken in accordance with **2.6.2 3)**, (see Figure 3C), a count shall be made of the particles in each of two circles of area 160 cm² (25 in²), i.e. diameter 14.3 cm (5.64 in), the centres of which shall be located within 2.5 cm (1 in) of two points central in the height of the zone and 23 cm (9 in) from and on each side of the point of impact; except that in the case of a small windscreen containing a zone of length less than 76 cm (30 in) but not less than 58 cm (23 in), the position of the assessed areas shall be such that no part of them shall be less than 7.5 cm (3 in) from the ends of the zone or from the point of impact. Within the permitted limits of location, the two circles of area 160 cm² (25 in²) shall be so placed that the fragmentation requirements of **2.6.4.3** are most likely to be satisfied. In the case of a heat-treated windscreen containing a non-uniform zone Type Z2, a count shall first be made in each circle of the number of disks of diameter 12.7 mm (0.5 in) which may be placed on particles or included portions of particles without overlapping the edges of the particles. One or two disks may be placed on any one particle but if two disks are placed on one particle they shall not overlap.

If the count in each circle satisfies the requirements of **2.6.4.3** below:

- 1) A further count shall be made of the particles in a square of side 5 cm (2 in) situated in the region of coarsest fracture in the marginal area of the glass of width at least 6 cm (2.5 in) (excluding three small segments (S) on both top and bottom edges opposite to and on either side of the point of impact). Additionally, if any of the small segments show a markedly coarser fracture than in this square, a further count shall be made in the coarsest of them.
- 2) The whole windscreen, excluding a circle of radius 7.5 cm (3 in) centred on the point of impact, shall be examined for pointed or flanged long particles, and the number of such particles of which a length exceeding 7.5 cm (3 in) is outside this circle shall be noted.
- 3) The presence of any individual particle of area exceeding 20 cm² (3 in²) shall also be noted.