

Road traffic signs — Testing and performance of microprismatic retroreflective sheeting materials — Specification

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- Aluminium Federation
- Association for Road Traffic and Safety Management
- British Electrotechnical and Allied Manufacturers' Association
- British Precast Concrete Federation
- County Surveyors' Society
- Department for Transport
- Institution of Civil Engineers
- Institution of Lighting Engineers
- Local Authority Sign Manufacturers Association
- Retroreflective Equipment Manufacturers Association

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Foreword

This British Standard has been prepared by Subcommittee B/509/3, assisted by international experts whose assistance has been invaluable and to whom thanks are due.

The specification of retroreflectivity in this standard differs from the traditional approach. Instead of specifying performance requirements against which a product is tested, the characteristics of microprismatic retroreflective sheetings are tested, and their performance rated for specific driving scenarios.

Annexes B and C are normative. All other annexes are informative.

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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 71 and a back cover.

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Introduction

In order to be effective, road signs need to be capable of being seen and either read or recognised. At night, this is effected primarily by the luminance of the sign. Retroreflective materials are widely used in road traffic signs because they improve sign luminance for drivers at night using the light from vehicle headlamps. The luminance of a sign depends upon the interaction of various factors, including the retroreflective material, the location of the sign relative to the vehicle, the vehicle's headlamp system and the vehicle's geometry.

The weighting of luminance through the viewing distance range is different for different sign types (directional or regulatory and warning). Other factors in addition to luminance affect how well a sign works in situ. These are: the visual acuity of drivers, the sign legend size relative to viewing distance, sign complexity, sign location (verge, overhead, etc) and sign surroundings.

In this standard, microprismatic retroreflective sign face sheetings are given separate photometric ratings depending on distance, entrance angularity, vehicle type and sign placement, all of which are factors in luminance, and sign type. The other factors have been set at levels consistent with common practice in the UK.

An assessment of performance has been made by comparing the luminance performance of the sheeting material with that which has been assumed to give satisfactory performance for a significant proportion of the driving population. This has been accomplished by modifying the work of Forbes and others in the United States to take account of UK research and experience over the past 40 years.

Microprismatic sheeting materials offer the potential to produce higher levels of retroreflection, and therefore luminance, than materials based on glass bead (microspheric) technology. However, the performance of microprismatic materials is sensitive to the location of the sign relative to the driver's eyes and the vehicle's headlamps. This can result in complex variation of the coefficient of retroreflection (R_A). In consequence, the photometric measurement procedures contained in this standard necessitate a comprehensive array of test points.

A luminance index system has been developed to rate the ability of a sign sheeting to provide the luminance required for drivers to read an appropriately-sized sign and to provide a minimum luminance for adequate conspicuity in most circumstances.

1 Scope

This British Standard specifies tests and performance requirements, and produces photometric ratings, for microprismatic retroreflective sheeting material for use in vertical road traffic signs. It is not applicable to materials based on glass bead technology (microspheric) or materials intended for use in microprismatic transilluminated signs.

NOTE 1 The retroreflective performance of microprismatic materials can be affected if the sign is tilted; the photometric rating method presumes verticality.

NOTE 2 This standard complements BS EN 12899-1, which specifies requirements for other components of vertical road traffic signs.

NOTE 3 Although the requirements of this British Standard are for the manufacturer of sign sheeting and the sign maker, Annex G and Annex I give guidance to the specifying road authority on the selection of, respectively, entrance angularity subclasses and sheeting.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 2782-5:Method 552A, *Methods of testing plastics — Optical and colour properties, weathering — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources.*

BS 4148:1985, *Specification for the abbreviation of title words and titles of publications.*

BS EN 28510-1, *Adhesives — Peel test for a flexible-bonded-to-rigid test specimen assembly — Part 1: 90° peel*

BS EN ISO 877, *Plastics — Methods of exposure to direct weathering, to weathering using glass-filtered daylight, and to intensified weathering by daylight using Fresnel mirrors.*

BS EN ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance.*

BS EN ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources.*

BS EN ISO 6272-1, *Paints and varnishes — Rapid-deformation (impact resistance) tests — Part 1: Falling-weight test, large-area indenter.*

ISO 7591, *Road vehicles — Retro-reflective registration plates for motor vehicles and trailers — Specification.*

CIE 15:2004: (third edition), *Colorimetry.*

CIE 17.4:1987, *International lighting vocabulary.*

CIE 54.2:2001, *Retroreflection: Definition and measurement.*

CIE 74:1988, *Roadsigns.*

NOTE CIE publications are available from the International Commission on Illumination. CIE Central Bureau, Kegelstrasse 27, A-1030 Vienna, Austria. +43 (01) 714 31 87/0 or www.cie.co.at

3 Terms and definitions

For the purposes of this British Standard, the symbols and abbreviations given in BS 4148, CIE 17.4 and CIE 74 and the following apply.

3.1

datum mark

visible mark or distinctive pattern on the sign sheeting from which the orientation of the datum axis or axes can be determined

NOTE The use of datum marks enables correct photometric testing and application to the substrate, and assists verification of correct sign manufacture and installation. See Annex A for examples.

3.2

datum axis

designated axis of a retroreflective sheeting with a direction perpendicular to the retroreflector axis

3.3

retroreflector axis

axis for retroreflective sheeting, normal to the surface

3.4

observation angle

α

angle between the illumination axis and the observation axis

3.5

entrance angle

β

angle between the illumination axis and the retroreflector axis

NOTE 1 In signing applications, the entrance angle is less than 90° .

NOTE 2 In the CIE goniometer system (CIE 54.2), β is resolved into two orthogonal components β_1 and β_2 . By definition β is always positive. β_1 and β_2 can be positive or negative.

3.6

orientation angle

ω_s

angle in a plane perpendicular to the retroreflector axis from the entrance half plane to the datum axis, measured counter-clockwise from the viewpoint of the source

NOTE The full range of the orientation angle is $-180^\circ < \omega_s \leq 180^\circ$.

3.7**rotation angle** **ϵ**

angle in a plane perpendicular to the retroreflector axis from the observation half plane to the datum axis, measured counter-clockwise from the viewpoint of the source

NOTE The full range of the rotation angle is $-180^\circ < \epsilon \leq 180^\circ$.

3.8**viewing angle** **ν**

angle between the observation axis and the retroreflector axis

NOTE 1 To determine the value of this angle by means of the CIE goniometer system (see CIE 54.2) the following equation applies:

$$\cos \nu = \cos(\beta_1 - \alpha) \cos \beta_2$$

NOTE 2 The full range of the viewing angle is $0^\circ \leq \nu < 90^\circ$.

3.9**substrate**

rigid material which supports the sheeting

3.10**luminance**

physical measure of stimulus which produces the sensation of brightness measured by the luminous intensity of light emitted or reflected in a given direction from a surface element divided by the area of the element projected in the same direction

NOTE The unit of measurement is candelas per square metre ($\text{cd} \cdot \text{m}^{-2}$).

3.11**luminance factor** **β**

ratio of the luminance of a surface to that of a perfect diffuse reflector, identically illuminated and viewed

NOTE The same symbol β is used for entrance angle and luminance factor.

3.12**luminance index**

unit-less rating for a sheeting based on the varying luminances of a sign made from that sheeting as observed through a distance range

3.13**performance index**

luminance index multiplied by the sign location correction factor

3.14**sign location correction factor**

factor which takes account of the varying illuminance on signs resulting from different lateral and vertical sign locations

3.15**retroreflection**

reflection in which the reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays, this property being maintained over wide variations in the direction of the incident rays

3.16**coefficient of retroreflection** **R_A**

luminous intensity of the sheeting in the direction of observation divided by the product of the illuminance on a plane perpendicular to the direction of incident light and the area of the sheeting

NOTE R_A is expressed in candelas per lux per square metre ($\text{cd} \cdot \text{lx}^{-1} \cdot \text{m}^{-2}$).

3.17**coefficient of reflected luminance** **R_L** quotient of the coefficient of retroreflection R_A and the cosine of the viewing angle ν NOTE R_L is expressed in candelas per square metre per lux ($\text{cd} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$).**3.18****fluorescent material**

material designed for enhanced daytime visibility using fluorescence

NOTE Fluorescence is primarily a daytime appearance attribute based on absorption of light at shorter wavelengths and emission at longer wavelengths.

3.19**non-fluorescent material**

material not designed for enhanced daytime visibility by the inclusion of fluorescence

4 Performance requirements**4.1 Exclusions from performance requirements**

White or coloured sheeting materials, which by their construction use no overlay or coating, shall conform to all the performance requirements in 4.2 and 4.3. Sheeting materials incorporating inks, overlay films or coatings shall satisfy all requirements, except for the optional exclusions in Table 1.

Where the manufacturer has designated more than one datum axis, photometric and colorimetric testing shall be conducted for all datum axes.

NOTE Where sheeting has more than one datum axis, physical testing need be done only once.

Table 1 — Exceptions to requirements

Requirements	Method of colouring			Additional clear layers	
	Self-coloured	Screen printed	Coloured overlay	Coating	Overlay film
Colorimetric	Test	Test	Test	No test ^a & ^d	No test ^a & ^d
Photometric	Test	Test	Test	Test white only ^b & ^c	Test white only ^b & ^c
Adhesion	Test	Test	No test ^a	Test	No test ^a
Salt spray	Test	No test ^a	No test ^a	No test ^a	No test ^a
Impact	Test	Test	No test ^a	Test	No test ^a
Hermeticity	Test	Test	No test ^a	Test	No test ^a
Natural weathering	Test	Test	Test	Test	Test
^a Provided that the underlying sheeting satisfies these requirements. ^b The approximate performance of coloured material with an additional clear layer is derived by applying the ratio between the white clear coated and uncoated material, to the measured value of the uncoated coloured sheeting, and this may serve as the performance rating. ^c Provided that any underlying sheeting with the same ink, overlay or coating meets the requirements. ^d Provided that the underlying sheeting is not fluorescent.					

4.2 Chromaticity**4.2.1 General**

Non-fluorescent and fluorescent material shall conform to the colorimetric requirements in 4.2.2 and 4.2.3 respectively, before and after accelerated natural weathering in accordance with 5.3.6.

NOTE 1 Where an early evaluation is sought, samples of materials may be subjected to accelerated artificial weathering, as described in 5.3.5.

NOTE 2 To avoid distraction to drivers and any reduction in legibility, the sheeting materials used to make traffic signs should exhibit uniformity of colour and appearance both by day and by night. The sheeting should be examined in conditions similar to those of intended final use.

4.2.2 Non-fluorescent material

4.2.2.1 Daytime chromaticity

When tested in accordance with 5.2.1.1, the chromaticity co-ordinates and luminance factor β for non-fluorescent material shall conform to Table 2.

Table 2 — Daytime chromaticity and luminance factor for non-fluorescent material

Colour	Chromaticity co-ordinates								Luminance factor, β
	1		2		3		4		
	x	y	x	y	x	y	x	y	
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	≥ 0.27
Yellow	0.545	0.454	0.487	0.423	0.427	0.483	0.465	0.534	≥ 0.16
Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429	≥ 0.12
Red	0.735	0.265	0.674	0.236	0.569	0.341	0.655	0.345	$0.03 \leq \beta \leq 0.12$
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	$0.015 \leq \beta \leq 0.06$
Light green	0.007	0.703	0.248	0.409	0.177	0.362	0.026	0.399	$0.03 \leq \beta \leq 0.10$
Dark green	0.313	0.682	0.313	0.453	0.248	0.409	0.127	0.557	$0.015 \leq \beta \leq 0.05$
Brown	0.455	0.397	0.523	0.429	0.558	0.394	0.479	0.373	$0.025 \leq \beta \leq 0.06$
Grey	0.350	0.360	0.300	0.310	0.285	0.325	0.335	0.375	$0.08 \leq \beta \leq 0.16$

NOTE When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.

4.2.2.2 Night-time chromaticity

When tested in accordance with 5.2.1.2, the night-time chromaticity for non-fluorescent material shall conform to Table 3.

Table 3 — Night-time chromaticity for non-fluorescent material

Colour	Chromaticity co-ordinates							
	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.475	0.452	0.360	0.415	0.392	0.370	0.515	0.409
Yellow	0.513	0.487	0.500	0.470	0.545	0.425	0.572	0.425
Orange	0.645	0.355	0.613	0.355	0.565	0.405	0.595	0.405
Red	0.652	0.348	0.620	0.348	0.712	0.255	0.735	0.265
Blue	0.033	0.370	0.180	0.370	0.230	0.240	0.091	0.133
Light green	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Dark green	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Brown	0.595	0.405	0.540	0.405	0.570	0.365	0.643	0.355
Grey	0.475	0.452	0.360	0.415	0.392	0.370	0.515	0.409

NOTE When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.

4.2.3 Fluorescent material

4.2.3.1 Day-time chromaticity

When tested in accordance with 5.2.2.1, the day-time chromaticity co-ordinates and the luminance factor for fluorescent material shall conform to Table 4.

Table 4 — Daytime chromaticity and luminance factor for fluorescent material

Colour	Chromaticity co-ordinates								Minimum luminance factor, β
	1		2		3		4		
	x	y	x	y	x	y	x	y	
Yellow-green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	0.60
Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	0.45
Orange	0.583	0.416	0.535	0.400	0.605	0.343	0.655	0.345	0.25
Red	0.735	0.269	0.671	0.275	0.613	0.333	0.666	0.334	0.18
NOTE When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.									

NOTE When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.

4.2.3.2 Night-time chromaticity

When tested in accordance with 5.2.2.2, the night-time chromaticity for fluorescent material shall conform to Table 5.

Table 5 — Night-time chromaticity for fluorescent material

Colour	Chromaticity co-ordinates							
	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow-green	0.550	0.449	0.524	0.439	0.472	0.492	0.480	0.520
Yellow	0.610	0.390	0.569	0.394	0.527	0.436	0.554	0.445
Orange	0.669	0.331	0.636	0.330	0.589	0.376	0.625	0.375
Red	0.735	0.265	0.680	0.320	0.622	0.342	0.663	0.301

NOTE When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.

4.3 Physical performance

4.3.1 Adhesion to the substrate

When tested in accordance with 5.3.1, the average peel strength shall not be less than 20 N per 25 mm of the sample sheeting width.

4.3.2 Salt spray resistance

After exposure to salt spray in accordance with 5.3.2, the coefficient of retroreflection R_A shall not be less than 90 % of its value before exposure.

4.3.3 Impact resistance

When tested in accordance with 5.3.3 there shall be no cracking of the sheeting or delamination of the sheeting from the substrate outside a circle of radius 6 mm with the point of impact as its centre.

4.3.4 Hermeticity of sheeting seals

When sheetings with a cell structure are tested in accordance with 5.3.4, no more than 3 % of the uncut cells shall be penetrated by water.

4.3.5 Resistance to accelerated artificial weathering

NOTE 1 The test for resistance to accelerated artificial weathering specified in 5.3.5 is optional for preliminary evaluation purposes.

4.3.5.1 When tested in accordance with 5.2.1 or 5.2.2 after exposure to accelerated artificial weathering in accordance with 5.3.5, the colour of the sheeting shall conform to the chromaticity requirements specified in Table 2 and Table 3 or Table 4 and Table 5, as appropriate.

4.3.5.2 After exposure to the accelerated artificial weathering, the sheeting shall not exhibit significant cracking, scaling, pitting, blistering, edge lifting, delamination, curling, shrinkage or expansion or other obvious defects.

NOTE 2 Where testing in accordance with 5.2.1 or 5.2.2 and 5.3.5 is employed for certification purposes, sheeting materials conforming to 4.3.5.1 and 4.3.5.2, and rated in accordance with Clause 6, are to be provisionally certified, once only, for a period of 48 months, provided that the sheeting material is concurrently being tested to 5.3.6.

4.3.6 *Resistance to accelerated natural weathering*

4.3.6.1 When tested in accordance with 5.2.1 or 5.2.2 after exposure to accelerated natural weathering in accordance with 5.3.6, the colour shall conform to the chromaticity requirements specified in Table 2 and Table 3 or Table 4 and Table 5, as appropriate.

4.3.6.2 After exposure to accelerated natural weathering, the sheeting shall not exhibit significant cracking, scaling, pitting, blistering, edge lifting, delamination, curling, shrinkage or expansion or other obvious defects.

NOTE Where testing in accordance with 5.2.1 or 5.2.2 and 5.3.6 is employed for certification purposes, sheeting materials conforming to 4.3.6.1 and 4.3.6.2, and rated in accordance with Clause 6, are to be certified for a period of 10 years. For final certification, luminance index ratings determined after accelerated natural weathering in accordance with 5.3.6 supersede those determined after accelerated artificial weathering in accordance with 5.3.5. Re-testing will be necessary if a manufacturer subsequently makes changes to a product which significantly change its performance. Sheeting materials that do not conform to 4.3.6.1 and 4.3.6.2 after accelerated natural weathering are not to be certified, even if samples were provisionally certified after testing in accordance with 5.3.5 (see NOTE 2 to 4.3.5).

5 Test methods

5.1 Samples

5.1.1 *Selection of samples*

Sheeting samples for performance testing shall be selected randomly, e.g. in accordance with one of the sampling procedures given in the BS 6001 and BS 6002 series of standards, and shall be representative of the normal production of the sheeting materials to be tested.

NOTE Guidance on the selection of sampling procedures from BS 6001 and BS 6002 is given in BS 6000.

5.1.2 *Preparation of samples for testing*

Samples of sheeting materials shall be mounted on (2.5 ± 0.5) mm thick aluminium substrate of a grade typically used in the manufacture of traffic signs, using the methods specified by the sheeting manufacturer for commercial application.

Unless otherwise specified elsewhere in this text:

- a) samples shall be (200 ± 5) mm $\times$ (200 ± 5) mm;
- b) samples shall be conditioned at (23 ± 2) °C and (50 ± 5) % relative humidity for 24 h prior to testing;
- c) tests shall be conducted at (23 ± 2) °C and (50 ± 5) % relative humidity.

5.2 Colorimetric testing

NOTE Colorimetric testing necessitates different test geometries and illuminants for daytime and night-time evaluation.

5.2.1 *Chromaticity of non-fluorescent material*

5.2.1.1 *Daylight chromaticity*

5.2.1.1.1 *Principle*

The daytime chromaticity co-ordinates and luminance factor of the sheeting material are assessed.

5.2.1.1.2 *Procedure*

Measurements of chromaticity co-ordinates shall be made in accordance with the procedures in CIE 15:2004. The measurements shall be made using the CIE 45°/0° (or 0°/45°) annular geometry. Calculation of the chromaticity co-ordinates and the luminance factor shall be based on CIE standard illuminant D65 and the 1931 CIE 2° standard observer.

5.2.1.2 *Night-time chromaticity*

5.2.1.2.1 *Principle*

The chromaticity of the sheeting material is assessed, as viewed under vehicle headlamp illumination in night-time conditions.

5.2.1.2.2 Procedure

Measurements of chromaticity co-ordinates shall be made in accordance with the procedures in CIE 15:2004, using:

- a) an observation angle $\alpha = 0.33^\circ$,
- b) an entrance angle of $\beta_1 = 5^\circ$ and $\beta_2 = 0^\circ$, and
- c) rotation angle $\varepsilon = 0^\circ$.

Neither the source nor the receptor aperture shall exceed 10 min of arc. Calculation of the chromaticity co-ordinates shall be based on CIE standard illuminant A and the 1931 CIE 2° standard observer in accordance with the principles set out in CIE 15:2004.

NOTE A worked example of the calculation of the night-time colour contrast factor is given in Annex H.

5.2.2 Chromaticity of fluorescent material

5.2.2.1 Daytime chromaticity

5.2.2.1.1 Principle

The daytime and night-time chromaticity co-ordinates and daytime luminance factor of the sheeting material are assessed.

5.2.2.1.2 Procedure

Measurements shall be made using CIE 45°/0° (or 0°/45°) annular geometry in accordance with the procedures in CIE 15:2004, using an instrument whose source accurately simulates CIE standard illuminant D65. The results shall be calculated on the basis of CIE standard illuminant D65 and the 1931 CIE 2° standard observer.

Simulation of CIE illuminant D65, for the purposes of this procedure, shall be considered adequate when the resulting luminance factor, measured on a non-retroreflective fluorescent specimen, is within ± 0.05 of that obtained with ideal instrumentation having D65 illumination.

The non-retroreflective fluorescent specimen shall incorporate the same colourants as the retroreflective fluorescent specimen. 0/45 or 45/0 geometry, for the purposes of this procedure, is considered adequate when the resulting luminance factor measured on a retroreflective non-fluorescent specimen is within 10 % of that obtained with instrumentation having 10° apertures for source and receiver. The retroreflective non-fluorescent specimen shall embody the same geometry as the retroreflective fluorescent specimen.

5.2.2.2 Night-time chromaticity

5.2.2.2.1 Principle

The night-time chromaticity co-ordinates of the material are assessed.

5.2.2.2.2 Procedure

Measurements shall be taken in accordance with 5.2.1.2.

5.3 Physical testing

5.3.1 Adhesion to the substrate

5.3.1.1 Principle

The resistance of the sheeting material to removal from the substrate is determined.

5.3.1.2 Procedure

Test three samples of the sheeting material, each fixed to a rigid aluminium substrate, in accordance with the procedure in BS EN 28510-1.

5.3.1.3 Test report

Report the average peel strength in Newtons per 25 mm sample width.

5.3.2 Salt spray resistance**5.3.2.1 Principle**

The resistance of the sheeting material to salt spray in the atmosphere and its effect on the sheeting material's efficacy is determined.

5.3.2.2 Apparatus

5.3.2.2.1 Means of producing a mist of saline solution, made of five parts by weight of sodium chloride dissolved in 95 parts of distilled water containing not more than 0.02 % of impurities.

5.3.2.3 Procedure

Measure R_A of the sample sheeting in accordance with CIE 54.2 at an observation angle of 0.33° and entrance angle of 5° ($\alpha = 0.33^\circ$, $\beta_1 = 5^\circ$, $\beta_2 = 0^\circ$ and $\varepsilon = 0^\circ$) before and after exposure to the salt spray test described in ISO 7591, at $(35 \pm 2)^\circ\text{C}$ for two periods of exposure of 22 h each, allowing the sample to dry between periods of exposure. Wash the sample with clean water and dry.

Compare R_A values measured after exposure with those obtained on the same sample prior to exposure.

5.3.2.4 Test report

Report the details of the test and substrate used to mount the sample. Report any change in R_A values.

5.3.3 Resistance to impact**5.3.3.1 Principle**

The impact resistance of microprismatic sheeting materials is determined.

5.3.3.2 Apparatus

The apparatus shall conform to ISO 6272-1, only using a hard body with a mass of (450 ± 5) g and a contact radius of (50 ± 1) mm which is dropped from a height of (220 ± 2) mm.

5.3.3.3 Procedure

Condition the test samples for 24 h at $(0 \pm 5)^\circ\text{C}$.

Support the test sample (see 5.1.2) horizontally over an open area $100\text{ mm} \times 100\text{ mm}$ on two parallel steel spacers 100 mm apart.

Drop the hard body once on the centre of the sample from a height of (250 ± 2) mm.

Examine the sample for visible signs of damage outside a circle of radius 6 mm with the point of impact as centre.

5.3.3.4 Test report

Report details of any damage observed.

5.3.4 Hermeticity of sheeting seals**5.3.4.1 Principle**

The hermeticity of the cells comprising the optical system of the sheeting is tested.

5.3.4.2 Apparatus

5.3.4.2.1 Two baths, capable of holding water at a constant temperature.

5.3.4.3 Procedure

Place a mounted sample of sheeting measuring $(100 \pm 2)\text{ mm} \times (100 \pm 2)\text{ mm}$ in water at a temperature of $(50 \pm 3)^\circ\text{C}$ for 1 h, the highest point of the surface being 20 mm below the surface of the water. Remove the sample and immediately immerse it in water at $(0_{-0}^{+3})^\circ\text{C}$.

Repeat the procedure for four cycles.

Examine the cells visually to check for water penetration.

5.3.4.4 Test report

Report any water penetration of cells.

5.3.5 Accelerated artificial weathering

NOTE This test is optional for early evaluation purposes.

5.3.5.1 Principle

Early failure in performance under exposure to weathering influences is detected and samples for other tests are prepared.

5.3.5.2 Apparatus

5.3.5.2.1 Air-cooled or water-cooled xenon arc weathering device, capable of exposing samples in accordance with BS EN ISO 4892-2.

5.3.5.3 Preparation of the test specimen

Prepare the test specimens in accordance with the general guidance given in BS EN ISO 4892-1. Only test specimens suitable for the weathering apparatus used for this test shall be supplied for testing.

5.3.5.4 Procedure

Expose the test sample to artificial weathering in accordance with Table 6 and condition the sample as specified in 5.1.2.

Expose the sample of sheeting material in accordance with BS EN ISO 4892-2, using the parameters given in Table 6, for a period of 2 000 h.

Table 6 — Artificial weathering test: test parameters

Exposure parameter	Air-cooled lamp	Water-cooled lamp
Light/dark/water spray cycle	Continuous light with water spray on specimens for 18 min every 2 h	Continuous light with water spray on specimens for 18 min every 2 h
Black standard temperature	$(65 \pm 3) ^\circ\text{C}$ using a black standard thermometer	$(65 \pm 3) ^\circ\text{C}$ using a black standard thermometer
Relative humidity during dry periods	$(50 \pm 5) \%$	$(50 \pm 5) \%$
Irradiance: — within 300 – 400 nm range — within 300 – 800 nm range	60 W/m ² total 550 W/m ² total	0.50 W/m ² /nm @ 340 nm 550 W/m ² total

5.3.5.5 Test report

The analysis and presentation of results shall be in accordance with BS 2782-5:Method 552A. Defects in the sheeting material sample shall be described and reported.

5.3.6 Accelerated natural weathering**5.3.6.1 Principle**

Failure in performance under long-term exposure to weathering influences is detected and samples for other tests are prepared.

5.3.6.2 Apparatus

5.3.6.2.1 Racks, to support the samples at least 1 m above the level of the test site and at an angle of 45° to the horizontal, facing the equator.

5.3.6.3 Procedure

Expose three samples of sheeting material on the rack for three years in a tropical, summer, rain climate type (BS EN ISO 877, class B1, Aw). Position the racks so that the samples are not overshadowed or protected by neighbouring objects. Ensure that the backs of the samples are freely exposed to weathering and that the samples are not in electrical contact with metals or in direct contact with wood or other porous

material during the exposure period. Take such steps as are necessary to prevent drainage from one sample to another.

Leave the samples undisturbed throughout the period of the test. Examine the samples visually for any change in appearance at six-monthly intervals and report any changes. Select one undamaged sample, at random, at the end of the three-year period. Gently wash the test samples using a soft cloth or sponge with clean water or a dilute solution (1 % by weight in water, maximum concentration) of a mild detergent. After washing, rinse thoroughly with clean water, and blot dry with a clean soft cloth. After washing and drying, conduct any property measurements.

NOTE South Florida is an example of a class BI, Aw climate type.

5.3.6.4 Test report

Report the results of the tests. Defects shall be described and reported.

6 Photometric rating

6.1 Calculation of the luminance index rating

The procedure specified in 6.2 to 6.9 shall be performed on samples of sheeting material before and after accelerated natural weathering in accordance with 5.3.6, in accordance with CIE 54.2, using the CIE standard $V(\lambda)$ photopic photometer and CIE standard illuminant A. The light source and photometer head apertures shall each subtend 6 min of arc. The angles, observation angle α , entrance angle β , rotation angle ϵ , and orientation angle ω_s , and the equipment specified in Annex B shall be used.

NOTE Measurements may be taken before and after weathering in accordance with 5.3.5 where a preliminary evaluation is sought.

6.2 Entrance angularity subclasses

The values of entrance angle β and orientation angle ω_s used to calculate the value of R_A for each observation angle, as described in 6.3, shall conform to Table 7.

NOTE 1 The values of orientation angle, ω_s , for measurement at each entrance angle take into account the orientation angles which arise from signs having these entrance angles and the sensitivity of microprismatic sheetings to orientation angle at these entrance angles.

NOTE 2 Entrance angularity refers to how a sign might be “twisted” to the right or left or viewed from an angle other than head-on, such as at roundabouts or bends. A specifier’s guide to selecting entrance angularity subclasses is given in Annex G.

Table 7 — Entrance angularity subclasses

Entrance angularity subclass	Entrance angle β	Orientation angle ω_s
A1 narrow	5°	0°
	15°	–90°, 0°, +90°
A2 medium	5°	0°
	15°	–90°, 0°, +90°
	30°	–90°, –75°, +75°, +90°
A3 wide	5°	0°
	15°	–90°, 0°, +90°
	30°	–90°, –75°, +75°, +90°
	40°	–90°, –75°, +75°, +90°

6.3 Observation angle α

Twelve observation angles identified by the method for selecting observation angles associated with viewing distance ranges and vehicle types specified in Annex D shall be used in the calculation of the luminance index: 0.25°, 0.30°, 0.40°, 0.50°, 0.65°, 0.90°, 1.20°, 1.50°, 2.00°, 2.50°, 3.00° and 4.00°. For each value of the observation angle α , the sheeting shall be measured at the geometries specified in Table 8, resulting in 12 tables of 36 values. The coefficient of retroreflection R_A shall be measured for each of these 432 angle combinations.

NOTE 1 The angle combinations are described in Table 8 using application geometry (see also Table E.1 to Table E.12). The 36 combinations of β , ϵ and ω_s specified in Table 8 are in practice measured using the equivalent angles (β_1 , β_2 , ϵ) given in Table 9.

NOTE 2 A complete worked example showing all the luminance index calculations is given in Annex E.

Table 8 — Measurement angles as described using the application reference system

Angles for measurement for $\alpha = 0.25^\circ, 0.30^\circ, 0.40^\circ, 0.50^\circ, 0.65^\circ, 0.90^\circ, 1.20^\circ, 1.50^\circ, 2.00^\circ, 2.50^\circ, 3.00^\circ$ and 4.00°						
β	ϵ	ω_s	ω_s	ω_s	ω_s	ω_s
5°	-45°			0°		
	0°			0°		
	$+45^\circ$			0°		
15°	-45°	-90°		0°		$+90^\circ$
	0°	-90°		0°		$+90^\circ$
	$+45^\circ$	-90°		0°		$+90^\circ$
30°	-45°	-90°	-75°		$+75^\circ$	$+90^\circ$
	0°	-90°	-75°		$+75^\circ$	$+90^\circ$
	$+45^\circ$	-90°	-75°		$+75^\circ$	$+90^\circ$
40°	-45°	-90°	-75°		$+75^\circ$	$+90^\circ$
	0°	-90°	-75°		$+75^\circ$	$+90^\circ$
	$+45^\circ$	-90°	-75°		$+75^\circ$	$+90^\circ$

NOTE 1 Table 9 gives the corresponding values of β_1 and β_2 for testing using the CIE goniometric system described in CIE 54.2 (see Figure B.2).

NOTE 2 The three steps of the rotation angle ϵ in Table 8 and Table 9 relate to the relative positions of the headlamp and the observer. They are included to accommodate non-uniformity of the retroreflected beam.

NOTE 3 The values of ω_s for the composition of β by its components β_1 and β_2 in Table 8 and Table 9 relate to the direction of illumination of the sign relative to the datum axis of the retroreflective material.

6.4 Reduction of rotation angles

To obtain the average values of R_A for each combination of α and β , the mean value of R_A , measured at ϵ equal to -45° , 0° and $+45^\circ$ shall be calculated for each of the values of ω_s specified in Table 9. The resulting tabulation of 144 average R_A values shall be arranged in the format shown in Figure 1 (see Note).

NOTE In this and subsequent figures, letters enclosed in square brackets, e.g. $[R_A]$ and $[L]$, indicate that a value is to be inserted following testing of the sheeting material.

6.5 Reduction of orientation angles

From the values tabulated in the sample form in Figure 1, the minimum value for each of the orientation angles for each combination of α and β shall be entered in the sample form shown in Figure 2.

NOTE 1 This is the value to be set against that combination of α and β .

Repeat this reduction process for every combination of α and β to populate a table of 48 values in the sample form shown in Figure 2.

NOTE 2 This reduction ensures that the sign performs equally well when twisted either clockwise (ω_s in the approximate range -90° to -75°) or counter-clockwise (ω_s in the approximate range $+75^\circ$ to $+90^\circ$).

Observation angle α	Entrance angle β	Orientation angle, ω_s				
		-90°	-75°	0°	$+75^\circ$	$+90^\circ$
0.25°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
0.30°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
0.40°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
0.50°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
0.65°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
0.90°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
1.20°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
1.50°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
2.00°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
2.50°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
3.00°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]
4.00°	5°			[R _A]		
	15°	[R _A]		[R _A]		[R _A]
	30°	[R _A]	[R _A]		[R _A]	[R _A]
	40°	[R _A]	[R _A]		[R _A]	[R _A]

Figure 1 — R_A values reduced for mean of three epsilon (ε) values -45°, 0° and +45°

Table 9 — Composition of β by its components β_1 and β_2

β	ϵ		$\omega_s = -90^\circ$	$\omega_s = -75^\circ$	$\omega_s = 0^\circ$	$\omega_s = +75^\circ$	$\omega_s = +90^\circ$
5°	-45°	β_1			3.5		
		β_2			3.5		
	0°	β_1			5.0		
		β_2			0.0		
	45°	β_1			3.5		
		β_2			-3.5		
15°	-45°	β_1	10.5		10.5		-10.5
		β_2	-10.7		10.7		10.7
	0°	β_1	0.0		15.0		0.0
		β_2	-15.0		0.0		15.0
	45°	β_1	-10.5		10.5		10.5
		β_2	-10.7		-10.7		10.7
30°	-45°	β_1	20.7	25.7		-14.5	-20.7
		β_2	-22.2	-16.1		-26.6	22.2
	0°	β_1	0.0	7.4		7.4	0.0
		β_2	-30.0	-29.1		29.1	30.0
	45°	β_1	-20.7	-14.5		25.7	20.7
		β_2	-22.2	-26.6		16.1	22.2
40°	-45°	β_1	27.0	33.8		-18.7	-27.0
		β_2	-30.7	-22.8		36.0	30.7
	0°	β_1	0.0	9.6		9.6	0.0
		β_2	-40.0	-39.0		39.0	40.0
	45°	β_1	-27.0	-18.7		33.8	27.0
		β_2	-30.7	-36.0		22.8	30.7

NOTE 1 The three steps of the rotation angle ϵ in Table 8 and Table 9 relate to the relative positions of the headlamp and the observer. They are included to accommodate non-uniformity of the retroreflected beam.

NOTE 2 The values of ω_s for the composition of β by its components β_1 and β_2 in Table 8 and Table 9 relate to the direction of illumination of the sign relative to the datum axis of the retroreflective material.

Entrance angle, β	Observation angle, α											
	0.25	0.30	0.40	0.50	0.65	0.90	1.20	1.50	2.00	2.50	3.00	4.00
5°	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]
15°	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]
30°	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]
40°	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]	[R _A]

Figure 2 — R_A values reduced to lowest value of R_A at the relevant orientation angles (ω_s) from Figure 1

6.6 Conversion to R_L values

The R_L values shall be converted from R_A values by dividing each of the values obtained for the sample form in Figure 2 by the appropriate values of $\cos v$ shown in Table 10, where v is the viewing angle ($R_L = R_A / \cos v$).

NOTE For all practical purposes, $\cos v$ closely approximates $\cos \beta$. The results are tabulated in the sample form shown in Figure 3.

Table 10 — Values of $\cos v$ by entrance angle β

β	$\cos v$
5°	0.996
15°	0.966
30°	0.866
40°	0.766

Entrance angle, β	Observation angle, α											
	0.25	0.30	0.40	0.50	0.65	0.90	1.20	1.50	2.00	2.50	3.00	4.00
5°	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]
15°	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]
30°	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]
40°	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]

Figure 3 — R_A values converted to R_L values (coefficient of reflected luminance)

The R_L values shall then be reduced by angularity subclass (see Table 7 and Figure 4). The lowest R_L value for each subclass shall then be used in subsequent luminance calculations.

Entrance angularity subclass	Observation angle, α											
	0.25	0.30	0.40	0.50	0.65	0.90	1.20	1.50	2.00	2.50	3.00	4.00
A1 narrow	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]
A2 medium	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]
A3 wide	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]	[R_L]

Figure 4 — R_L values reduced for entrance angularity subclasses

6.7 Luminance index ratings

6.7.1 Colour factors

The colour factors in Table 11, giving the relative retroreflectance of coloured and white material at night, shall be used in the procedure in 6.7.2 to determine the luminance index [see NOTE 3 to each of Figure 5A, Figure 5B, Figure 6A and Figure 6B].

Table 11 — Colour factors

Colour	Colour factors
White	1.0
Yellow-green	0.8
Yellow	0.7
Yellow (fluorescent)	0.6
Orange	0.4
Orange (fluorescent)	0.3
Red	0.2
Blue	0.05
Light green	0.10
Dark green	0.05
Brown	0.015
Grey	0.5

6.7.2 Conversion to luminance index ratings

The coefficient of reflected luminance shall be converted to luminance index ratings (see Annex F) for each of the two luminance indices, A and B, for each vehicle type (car and large vehicle in Table D.3) and entrance angularity subclass (A1, A2 and A3 in Table 7) and for each viewing distance subclass (D1, D2, D3 and D4 in Table D.1) for which the material is to be rated.

NOTE 1 For each of the viewing distance subclasses and each of the vehicle types, groups of observation angles are selected, in accordance with Table D.6, for inclusion in the luminance calculation.

NOTE 2 The luminance index is based on the worst-case R_L value obtained for the sample form in Figure 3 for the β angles relevant to each entrance angularity subclass. In practice, for most materials, the three entrance angularity classes relate to performance at the largest entrance angle (15°, 30° or 40°) included in the ranges set out in Table 7. These worst-case values are tabulated in the sample form in Figure 4.

For each of the distance ranges in Table D.1 and for each vehicle type in Table D.3 a luminance performance, L , shall be calculated by multiplying R_L by the illuminance E associated with the test distance from the reference headlamp distribution in Annex C. Thus:

$$L = R_L E$$

NOTE 3 A worked example is given in Annex E.

The results shall be tabulated in the format shown in Figure 5 (passenger cars) and Figure 6 (large vehicles) and the luminance index determined following the procedure set out in the notes to these figures. This results in twelve tables, one for each vehicle type and entrance angularity subclass.

The resulting luminance values shall be converted to ratios against basis values (see Annex F). These ratios shall be combined into an uncorrected luminance index, which shall then be modified to the corrected luminance index as shown in Figure 5 and Figure 6. The performance index of the sheeting material shall be calculated from the corrected luminance index (see Annex I). Values of the performance index greater than 1.0 shall be regarded as indicating that the sheeting is satisfactory in service for a near side verge-mounted sign no higher than 2.5m above carriageway level.

NOTE 4 See 6.9 for correction for other sign locations.

NOTE 5 This procedure is intended to assess the degree to which a material satisfies the driver's need for luminance over any viewing distance subclass.

V1 Passenger car		Luminance (cd·m ⁻²)											
		Distance subclass											
Observation angle α	Illuminance E _{lx}	D1 Long (200–50m)			D2 Medium (120–40m)			D3 Short (90–30m)			D4 Close (50–20m)		
		L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)
0.25	0.027	[L]	10	[b/L]									
0.30	0.037	[L]	4	[b/L]									
0.40	0.058	[L]	3	[b/L]	[L]	10	[b/L]						
0.50	0.078				[L]	4	[b/L]	[L]	10	[b/L]			
0.65	0.106	[L]	3	[b/L]	[L]	3	[b/L]	[L]	4	[b/L]			
0.90	0.174				[L]	3	[b/L]	[L]	3	[b/L]	[L]	10	[b/L]
1.20	0.259							[L]	3	[b/L]	[L]	4	[b/L]
1.50	0.361										[L]	3	[b/L]
2.00	0.341										[L]	3	[b/L]
V1 Uncorrected Luminance Index A (see NOTE 2)		[V1ULIA]			[V1ULIA]			[V1ULIA]			[V1ULIA]		
Colour factor (see Table 11)		[CF]			[CF]			[CF]			[CF]		
V1 Luminance Index A (see NOTE 3)		[V1LIA]			[V1LIA]			[V1LIA]			[V1LIA]		
NOTE 1 The ratio is obtained by dividing the basis value by the luminance value.													
NOTE 2 The uncorrected luminance index is obtained by dividing four by the sum of the values in the ratio column.													
NOTE 3 The luminance index is obtained by dividing the uncorrected luminance index by the appropriate colour factor.													
Figure 5A — Luminance Index A (for directional signs) calculations for V1 passenger car for one entrance angularity subclass: A1 or A2 or A3													

V1 Passenger car		Luminance (cd·m ⁻²)											
		Distance subclass											
Observation angle α	Illuminance E _{lx}	D1 Long (200–50m)			D2 Medium (120–40m)			D3 Short (90–30m)			D4 Close (50–20m)		
		L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)	L	basis	ratio (see NOTE 1)
0.25	0.027	[L]	3	[b/L]									
0.30	0.037	[L]	3	[b/L]									
0.40	0.058	[L]	3	[b/L]	[L]	3	[b/L]						
0.50	0.078				[L]	3	[b/L]	[L]	3	[b/L]			
0.65	0.106	[L]	3	[b/L]	[L]	3	[b/L]	[L]	3	[b/L]			
0.90	0.174				[L]	3	[b/L]	[L]	3	[b/L]	[L]	3	[b/L]
1.20	0.259							[L]	3	[b/L]	[L]	3	[b/L]
1.50	0.361										[L]	3	[b/L]
2.00	0.341										[L]	3	[b/L]
V1 Uncorrected Luminance Index B (see NOTE 2)		[V1ULIB]			[V1ULIB]			[V1ULIB]			[V1ULIB]		
Colour factor (see Table 11)		[CF]			[CF]			[CF]			[CF]		
V1 Luminance Index B (see NOTE 3)		[V1LIB]			[V1LIB]			[V1LIB]			[V1LIB]		
NOTE 1 The ratio is obtained by dividing the basis value by the luminance value.													
NOTE 2 The uncorrected luminance index is obtained by dividing four by the sum of the values in the ratio column.													
NOTE 3 The luminance index is obtained by dividing the uncorrected luminance index by the appropriate colour factor.													
Figure 5B — Luminance Index B (for warning and regulatory signs) calculations for V1 passenger car for one entrance angularity subclass: A1 or A2 or A3													