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

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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.

Compliance with a British Standard does not of itself 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 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 $-180° < \omega_s \leqslant 180°$.

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 $-180° < \varepsilon \leqslant 180°$.

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 $0° \leqslant \nu < 90°$.

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 ($cd \cdot m^{-2}$).

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
$\mathbf{R_A}$
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 ($cd \cdot lx^{-1} \cdot m^{-2}$).

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 ($cd \cdot m^{-2} \cdot lx^{-1}$).

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 ⩽ β ⩽ 0.12
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	0.015 ⩽ β ⩽ 0.06
Light green	0.007	0.703	0.248	0.409	0.177	0.362	0.026	0.399	0.03 ⩽ β ⩽ 0.10
Dark green	0.313	0.682	0.313	0.453	0.248	0.409	0.127	0.557	0.015 ⩽ β ⩽ 0.05
Brown	0.455	0.397	0.523	0.429	0.558	0.394	0.479	0.373	0.025 ⩽ β ⩽ 0.06
Grey	0.350	0.360	0.300	0.310	0.285	0.325	0.335	0.375	0.08 ⩽ β ⩽ 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.

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 × (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 $\alpha = 0.33°$,

b) an entrance angle of $\beta_1 = 5°$ and $\beta_2 = 0°$, and

c) rotation angle $\varepsilon = 0°$.

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° (α = 0.33°, β_1 = 5°, β_2 = 0° and ε = 0°) before and after exposure to the salt spray test described in ISO 7591, at (35 ± 2) °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 ± 5) °C.

Support the test sample (see **5.1.2**) horizontally over an open area 100 mm × 100 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 ± 2) mm × (100 ± 2) mm in water at a temperature of (50 ± 3) °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^{+3}_{-0}) °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 ± 3) °C using a black standard thermometer	(65 ± 3) °C using a black standard thermometer
Relative humidity during dry periods	(50 ± 5) %	(50 ± 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(λ) 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 RA 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 α = 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°						
β	ε	ω_s	ω_s	ω_s	ω_s	ω_s
5°	–45°			0°		
	0°			0°		
	+45°			0°		
15°	–45°	–90°		0°		+90°
	0°	–90°		0°		+90°
	+45°	–90°		0°		+90°
30°	–45°	–90°	–75°		+75°	+90°
	0°	–90°	–75°		+75°	+90°
	+45°	–90°	–75°		+75°	+90°
40°	–45°	–90°	–75°		+75°	+90°
	0°	–90°	–75°		+75°	+90°
	+45°	–90°	–75°		+75°	+90°

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° 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° to +90°).

Observation angle α	**Entrance angle β**	**Orientation angle, ω_s**				
		–90°	**–75°**	**0°**	**+75°**	**+90°**
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		ω_s = –90°	ω_s = –75°	ω_s = 0°	ω_s = +75°	ω_s = +90°
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 ν shown in Table 10, where ν is the viewing angle ($R_L = R_A/\cos \nu$).

NOTE For all practical purposes, cos ν closely approximates cos β. The results are tabulated in the sample form shown in Figure 3.

Table 10 — Values of cos ν by entrance angle β

β	cos ν
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											
Obser-vation angle α	Illumi-nance 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 ($cd \cdot m^{-2}$)											
		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

V2 Large vehicle		**Luminance (cd·m^{-2})**											
		Distance subclass											
Obser-vation angle α	Illumi-nance 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)
0.50	0.022	[L]	10	[b/L]									
0.65	0.035	[L]	4	[b/L]									
0.90	0.061	[L]	3	[b/L]	[L]	10	[b/L]						
1.20	0.089				[L]	4	[b/L]	[L]	10	[b/L]			
1.50	0.117	[L]	3	[b/L]	[L]	3	[b/L]	[L]	4	[b/L]			
2.00	0.180				[L]	3	[b/L]	[L]	3	[b/L]	[L]	10	[b/L]
2.50	0.252							[L]	3	[b/L]	[L]	4	[b/L]
3.00	0.326										[L]	3	[b/L]
4.00	0.398										[L]	3	[b/L]
V2 Uncorrected Luminance Index A (see NOTE 2)		[V2ULIA]			[V2ULIA]			[V2ULIA]			[V2ULIA]		
Colour factor (see Table 11)		[CF]			[CF]			[CF]			[CF]		
V1 Luminance Index A (see NOTE 3)		[V2LIA]			[V2LIA]			[V2LIA]			[V2LIA]		

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 6A — Luminance Index A (for directional signs) calculations for V2 large vehicle for one entrance angularity subclass: A1 or A2 or A3

V2 Large vehicle		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)
0.50	0.022	[L]	3	[b/L]									
0.65	0.035	[L]	3	[b/L]									
0.90	0.061	[L]	3	[b/L]	[L]	3	[b/L]						
1.20	0.089				[L]	3	[b/L]	[L]	3	[b/L]			
1.50	0.117	[L]	3	[b/L]	[L]	3	[b/L]	[L]	3	[b/L]			
2.00	0.180				[L]	3	[b/L]	[L]	3	[b/L]	[L]	3	[b/L]
2.50	0.252							[L]	3	[b/L]	[L]	3	[b/L]
3.00	0.326										[L]	3	[b/L]
4.00	0.398										[L]	3	[b/L]
V2 Uncorrected Luminance Index B (see NOTE 2)		[V2ULIB]			[V2ULIB]			[V2ULIB]			[V2ULIB]		
Colour factor (see Table 11)		[CF]			[CF]			[CF]			[CF]		
V1 Luminance Index B (see NOTE 3)		[V2LIB]			[V2LIB]			[V2LIB]			[V2LIB]		

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 6B — Luminance Index B (for warning and regulatory signs) calculations for V2 large vehicle for one entrance angularity subclass: A1 or A2 or A3

6.8 Luminance index

The results of the tabulations in Figure 5 and Figure 6 for each entrance angularity subclass shall be entered in the layout given in the sample forms shown in Figure 7. Versions of the sample forms in Figure 7 shall be completed both before and after accelerated natural weathering in accordance with **5.3.6** (or, where applicable, accelerated artificial weathering in accordance with **5.3.5**). The final luminance index report shall be produced to indicate the lesser of the values in each cell for weathered and unweathered material.

NOTE The method of calculation and a worked example are given in Annex E [Table E.20A and Table E.20B are populated versions of Figure 7A and Figure 7B].

Entrance angularity subclass		A1 narrow 5°, 15°		A2 medium 5°, 15°, 30°		A3 wide 5°, 15°, 30°, 40°	
Vehicle type		Passenger car	Large vehicle	Passenger car	Large vehicle	Passenger car	Large vehicle
Distance subclass	D1 long	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]
	D2 medium	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]
	D3 short	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]
	D4 close	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]	[V1LIA]	[V2LIA]

Figure 7A — Luminance Index A values by subclass

Entrance angularity subclass		A1 narrow 5°, 15°		A2 medium 5°, 15°, 30°		A3 wide 5°, 15°, 30°, 40°	
Vehicle type		Passenger car	Large vehicle	Passenger car	Large vehicle	Passenger car	Large vehicle
Distance subclass	D1 long	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]
	D2 medium	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]
	D3 short	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]
	D4 close	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]	[V1LIB]	[V2LIB]

Figure 7B — Luminance Index B values by subclass

6.9 Sign location correction of luminance indexes

To accommodate the effect of sign location, the luminance index rating shall be corrected using the sign location factors given in Table 12 to produce the performance index (see **I.4.6**).

Table 12 — Sign location correction factors

Location category		Distance subclass							
		D1		D2		D3		D4	
		V1	V2	V1	V2	V1	V2	V1	V2
		Car	Large vehicle	Car	Large vehicle	Car	Large vehicle	Car	Large vehicle
P1	Left verge	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P2	Right verge	0.73	0.72	0.73	0.71	0.64	0.64	0.50	0.49
P3	Overhead	0.46	0.45	0.51	0.47	0.39	0.39	0.36	0.39
P4	Low left	2.75	3.19	7.98	9.04	9.92	13.79	9.38	11.62

7 Marking, labelling and product information

7.1 Marking

The documents accompanying the sheeting shall include the following information:

a) the number of this standard, i.e. BS 8408:2005[1)];

b) the mark of origin, i.e. trade mark, manufacturing site, manufacturer's identification mark or, if applicable, the name of responsible vendor; and

c) the luminance ratings of the retroreflective material for each datum axis.

7.2 Information

The manufacturer shall provide the following information with the sheeting:

a) a test certificate providing details of conformity to the physical and colorimetric requirements of this British Standard, and the luminance rating results in the format set out in **6.8**;

NOTE Evidence of testing in accordance with this standard, and any requirements for certification, can be provided by a third party Declaration of Test Results.

b) the expiry date of any conformity certificates;

c) instructions on the storage and handling of the material;

d) instructions on how to use the datum mark to determine the datum axis;

e) instructions on the application of the material to the substrate;

[1)] Marking BS 8408:2005 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

f) details of any limitations in usage; and

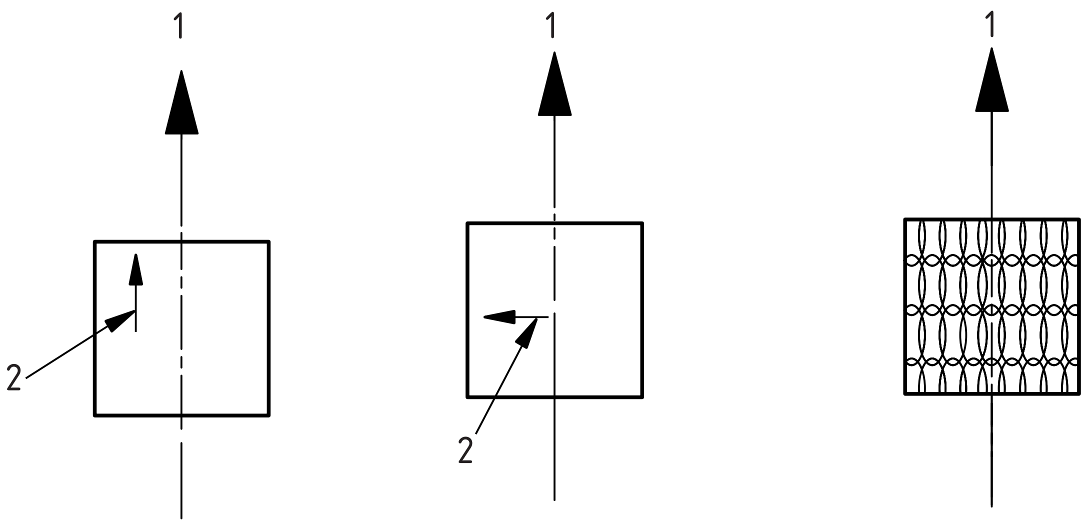
g) instructions on the care and maintenance of the material, including cleaning, once incorporated into the works or final product.

Annex A (informative) Examples of datum axes

The relationship between datum axes and datum marks can be better understood by using examples.

The datum mark for a sheeting can be a distinct pattern within a sheeting material or an intentional mark made on or in the sheeting. These datum marks are used to define one or more datum axes. The datum axis is always designated with the intention that it is oriented vertically upwards in the finished sign.

Three examples are shown below.



Example 1 **Example 2** **Example 3**

Key
1 = Datum axis
2 = Datum mark

Figure A.1 — Datum axes

Example 1

The manufacturer has defined the datum axis as parallel to the datum mark. The sample is tested using that datum axis. Both the datum axis and the datum mark are intended to be vertical in the finished sign.

Example 2

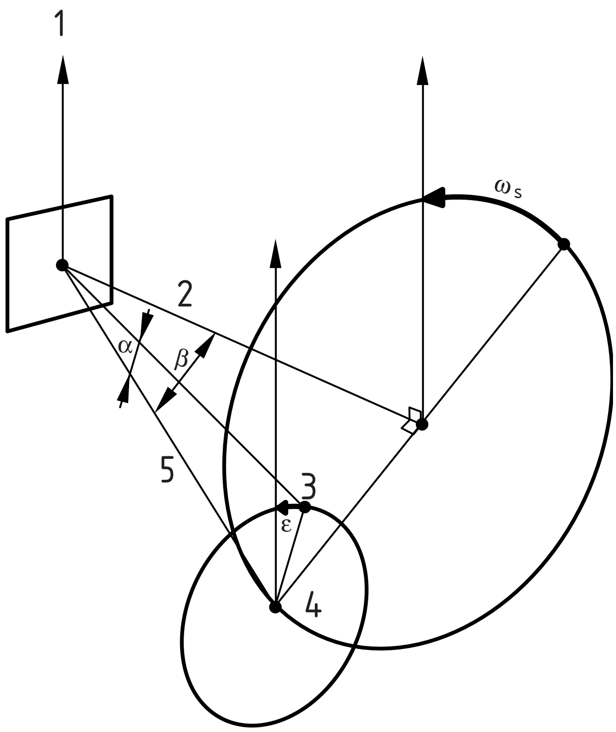
The manufacturer has defined the datum axis as perpendicular to the datum mark. The sample is tested using that datum axis. The datum axis is intended to be vertical and the datum mark horizontal in the finished sign.

Example 3

The sheeting is supplied with a distinct pattern integral to it, from which the datum axis or axes can be determined. In this example, the manufacturer has declared the datum axis to be parallel to the direction of the pattern. The sample is tested using that declared datum axis, which is intended to be vertical in the finished sign.

Annex B (normative) Angles and equipment used in specifying and measuring retroreflective performance

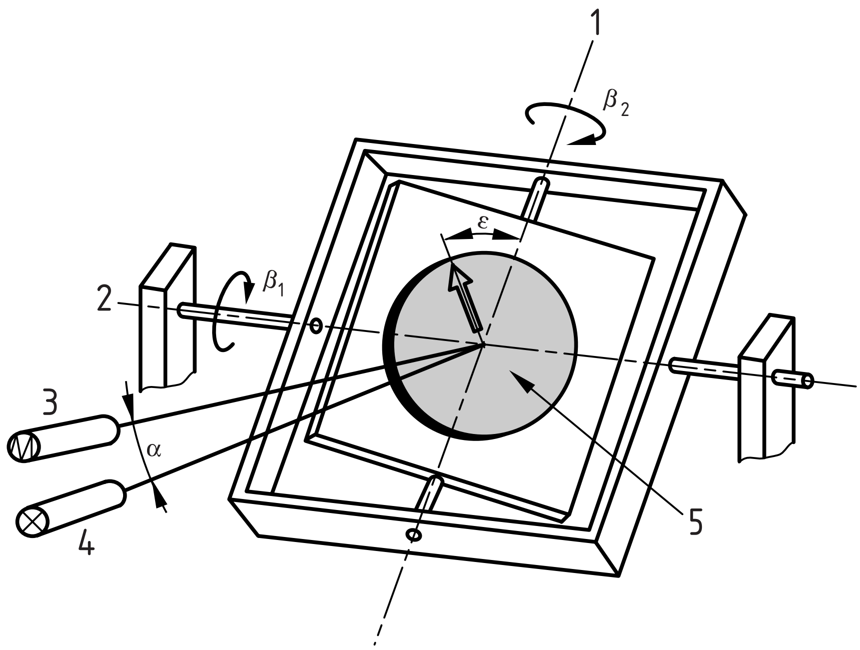
The angles and equipment shown in Figure B.1 and Figure B.2 shall be used to specify and measure retroreflective performance of microprismatic sheeting materials.



Key
1 = Datum axis
2 = Retroreflector axis
3 = Receiver
4 = Source
5 = Illumination axis

Figure B.1 — Application geometry

NOTE In the application system ε and ω_s are independent, whereas in the laboratory (CIE goniometer) system they are interdependent. In the laboratory when ε is changed and other angles fixed, then ω_s also changes.



Key
1 = Moveable axle (for motion about the second axis)
2 = Fixed axle (for motion about the first axis)
3 = Photometer head
4 = Source
5 = Retroreflector

Figure B.2 — CIE gonimeter diagram

NOTE Typical laboratory measuring equipment is based on the four angles α, β_1, β_2 an ε. The values of the laboratory angles can be derived from the defining angles by the equations:

$\beta_1 = \sin^{-1} (\sin\beta.\cos(\omega_s–\varepsilon))$
$\beta_2 = \tan^{-1} (\tan\beta.\sin(\omega_s–\varepsilon))$

Annex C (normative)
Headlamp light distribution used to determine luminance index

C.1 General

The illuminance values used in the luminance index calculation shall be determined in accordance with the procedure in **C.1** to **C.7**.

NOTE 1 The derived values correspond to the selected observation angles given in Table D.6. The determined illumination in lux represents the total value contributed by the left and right headlamps corresponding to viewing distances associated with the selected observation angles.

A correction shall be made for headlamp operating voltage. The final tabulation of corrected illuminance values shall be that used in the calculations in **6.7**.

NOTE 2 Computer simulation programs are capable of carrying out the calculations described in this annex. However, the procedure described here employs basic arithmetic and trigonometry so that it can easily be followed. The examples given are for the case of a verge-mounted sign on the left side of a straight road.

NOTE 3 The headlight photometric values are based on measurements made by the University of Michigan and reported in the UMTRI Report 2000-36, "*A market-weighted description of low-beam headlight patterns in Europe*" [1]. Here, the photometric values of 20 dipped beam headlamps representative of the best-selling European passenger cars in 1999 were taken at 12.8 V, using a goniometer as described in SAE J1330 [2]. The median photometric values obtained are regarded as typical. The horizontal angles are transformed from left to right to correspond to vehicles driving on the left hand side of the road.

The transformed values are shown in Table C.1.

NOTE 4 Although Table C.1 represents an accurate statistical composite, it does not necessarily represent the actual pattern from any single headlamp.

C.2 Determination of road distances relating to the observation angles selected

In order to find the illuminance on a sign, a distance from the sign shall be specified. This distance shall be based on the quartile distance ranges determined in accordance with Annex D or the distances associated with the observation angles chosen to represent the performance within the distance range quartiles. The observation angle approach shall be used. The road distance shall therefore be determined as the distance at which the mean observation angle (from left and right headlamps) corresponds to the selected observation angles in the viewing distance range class.

The road distance shall be determined using computer simulation modelling (see CIE 54.2). The observation angle shall be calculated for both the left and right headlamps at distances close to the desired observation angle for a distance midway in the quartile for a given distance range class. The distance shall be increased or decreased in small increments as necessary to make the mean observation angle correspond to the selected value for the test regime.

NOTE The results of computer simulation modelling for the passenger car and large vehicle types are shown in Table C.2.

Table C.1 — Transformed headlamp luminous intensity values in candelas for driving on the left based on UMTRI report 2000–36

Left part of beam pattern														
	left										toward centre			
up	**–45**	**–40**	**–35**	**–30**	**–25**	**–20**	**–15**	**–10**	**–9**	**–8**	**–7**	**–6**	**–5**	**up**
7	9	12	15	25	39	47	55	55	55	56	59	64	62	**7**
6.5	9	13	18	24	37	47	58	60	61	62	64	67	69	**6.5**
6	9	13	20	25	37	51	61	67	69	70	72	72	75	**6**
5.5	9	13	18	31	37	53	65	75	75	75	76	78	79	**5.5**
5	10	14	20	30	41	55	67	76	79	81	82	84	85	**5**
4.5	10	14	20	31	45	57	73	85	97	92	89	93	122	**4.5**
4	9	14	19	32	44	60	78	111	120	121	133	132	134	**4**
3.5	9	14	18	34	42	70	90	137	149	148	149	148	148	**3.5**
3	10	14	18	34	45	83	114	151	158	159	143	161	151	**3**
2.5	12	15	18	37	52	92	141	174	175	160	153	164	171	**2.5**
2	12	17	26	47	81	101	186	196	178	169	174	184	197	**2**
1.5	11	19	25	46	95	151	225	287	287	255	217	227	214	**1.5**
1	10	18	29	46	109	190	286	524	700	605	460	366	294	**1**
0.5	9	18	29	49	115	193	367	871	1 267	1 771	1 853	1 858	992	**0.5**
0	7	17	25	42	136	226	465	1 416	1 722	2 511	3 274	4 112	4 345	**0**
–0.5	5	10	24	66	138	326	579	1 690	2 426	3 083	4 172	5 310	6 527	**–0.5**
–1	5	5	20	72	156	363	875	2 532	3 221	3 576	4 886	6 260	8 183	**–1**
–1.5	5	9	20	90	194	410	1 306	3 168	3 799	4 702	5 516	7 775	9 535	**–1.5**
–2	5	5	24	134	250	743	1 490	3 398	4 084	4 839	6 504	8 085	9 384	**–2**
–2.5	5	5	36	148	317	901	2 137	4 014	4 158	4 669	5 509	6 837	8 142	**–2.5**
–3	5	5	52	160	334	885	2 503	3 674	3 795	4 534	5 617	6 826	7 464	**–3**
–3.5	5	10	78	166	360	997	2 543	3 728	3 986	4 716	5 548	6 156	6 525	**–3.5**
–4	5	13	82	171	410	1 311	2 669	3 290	3 928	4 426	5 039	5 484	5 547	**–4**
–4.5	7	22	90	156	461	1 431	2 363	3 184	3 743	4 223	4 703	4 824	4 897	**–4.5**
–5	9	37	83	169	483	1 259	2 088	3 004	3 705	3 758	4 102	4 311	4 475	**–5**
down														**down**

Table C.1 — Transformed headlamp luminous intensity values in candelas for driving on the left based on UMTRI report 2000–36
(continued)

Left central part of beam pattern												
	toward left									centre		
up	**–5**	**–4.5**	**–4**	**–3.5**	**–3**	**–2.5**	**–2**	**–1.5**	**–1**	**–0.5**	**0**	**up**
7	62	64	66	67	68	70	72	77	76	75	71	**7**
6.5	69	69	71	72	76	79	79	80	82	75	72	**6.5**
6	75	76	76	77	80	82	82	83	82	80	77	**6**
5.5	79	82	83	83	82	83	84	81	81	79	79	**5.5**
5	85	92	107	106	107	106	106	106	99	94	93	**5**
4.5	122	122	120	118	118	118	118	117	117	119	116	**4.5**
4	134	136	134	130	129	129	127	126	127	127	128	**4**
3.5	148	147	150	147	145	144	133	131	140	141	121	**3.5**
3	151	153	166	152	141	146	140	140	136	135	135	**3**
2.5	171	165	163	161	161	158	157	158	156	158	158	**2.5**
2	197	191	187	184	185	182	179	186	189	188	188	**2**
1.5	214	213	213	211	214	223	219	227	233	231	231	**1.5**
1	294	279	283	286	285	296	297	293	287	287	278	**1**
0.5	992	839	524	429	425	398	386	371	361	352	339	**0.5**
0	4 345	3 925	4 008	3 501	2 127	1 324	856	698	700	569	535	**0**
–0.5	6 527	7 103	9 334	10 659	11 059	10 118	6 966	4 718	3 233	2 299	1 400	**–0.5**
–1	8 183	9 129	10 875	12 935	14 431	15 413	15 554	16 252	15 806	12 840	10 230	**–1**
–1.5	9 535	10 391	11 844	13 951	15 084	15 764	16 527	17 327	17 458	17 526	16 940	**–1.5**
–2	9 384	10 195	11 930	13 768	14 947	16 720	18 082	19 473	19 176	20 389	17 721	**–2**
–2.5	8 142	9 290	10 487	11 513	12 409	13 812	15 317	15 460	15 504	15 240	14 760	**–2.5**
–3	7 464	8 371	9 056	9 417	9 776	10 776	11 268	11 321	11 360	11 548	11 482	**–3**
–3.5	6 525	6 656	6 821	7 385	7 800	8 311	8 565	8 528	8 731	8 952	8 565	**–3.5**
–4	5 547	5 788	5 969	6 179	6 242	6 659	6 849	7 003	6 976	6 666	6 437	**–4**
–4.5	4 897	4 994	5 178	5 355	5 535	5 573	5 548	5 394	5 325	5 340	5 364	**–4.5**
–5	4 475	4 491	4 534	4 571	4 556	4 618	4 555	4 594	4 691	4 594	4 518	**–5**
down												**down**

Table C.1 — Transformed headlamp luminous intensity values in candelas for driving on the left based on UMTRI report 2000–36 (*continued*)

Right central part of beam pattern											
	centre							toward right			
up	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**up**
7	71	69	65	64	62	60	61	60	59	60	59	**7**
6.5	72	71	69	68	66	67	66	66	66	65	62	**6.5**
6	77	75	73	72	71	69	68	69	67	64	63	**6**
5.5	79	80	81	77	75	74	72	70	69	70	72	**5.5**
5	93	91	87	84	82	84	85	85	82	84	79	**5**
4.5	116	111	108	106	96	92	88	83	81	81	81	**4.5**
4	128	118	110	102	98	96	94	92	91	90	89	**4**
3.5	121	118	118	113	108	106	105	103	102	99	98	**3.5**
3	135	132	129	128	124	122	119	116	113	113	116	**3**
2.5	158	155	152	147	144	141	137	132	128	127	125	**2.5**
2	188	185	181	176	170	164	160	154	149	145	142	**2**
1.5	231	225	219	209	211	204	197	191	184	174	170	**1.5**
1	278	276	278	269	258	256	252	232	227	219	213	**1**
0.5	339	334	333	329	316	301	294	284	273	264	258	**0.5**
0	535	492	462	424	419	396	374	373	371	361	359	**0**
–0.5	1 400	1 300	1 233	1 016	1 000	1 043	1 055	1 042	995	885	831	**–0.5**
–1	10 230	9 481	7 638	6 260	6 268	6 335	5 282	4 391	4 391	4 012	3 836	**–1**
–1.5	16 940	15 275	12 856	11 995	11 037	9 821	8 589	7 966	7 884	7 232	6 689	**–1.5**
–2	17 721	15 423	13 782	13 192	12 638	11 964	10 831	9 851	8 948	8 158	7 799	**–2**
–2.5	14 760	14 124	12 592	11 202	10 619	9 887	9 154	8 513	8 251	7 912	7 050	**–2.5**
–3	11 482	10 839	10 439	10 248	9 581	8 949	8 260	8 077	8 037	7 626	6 965	**–3**
–3.5	8 565	7 895	7 885	7 980	7 676	7 457	7 062	6 445	6 272	5 809	5 444	**–3.5**
–4	6 437	6 553	6 573	6 540	6 493	6 248	6 018	5 769	5 370	5 057	4 934	**–4**
–4.5	5 364	5 108	5 248	5 247	5 201	5 080	4 986	4 700	4 443	4 279	3 901	**–4.5**
–5	4 518	4 364	4 118	4 133	4 082	4 011	3 841	3 809	3 725	3 542	3 409	**–5**
down												**down**

Table C.1 — Transformed headlamp luminous intensity values in candelas for driving on the left based on UMTRI report 2000–36 (*continued*)

Right part of beam pattern													
	toward centre											right	
up	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**up**
7	59	56	54	52	52	52	44	41	35	28	22	22	30	**7**
6.5	62	59	58	57	56	55	49	41	35	32	23	22	31	**6.5**
6	63	63	63	60	62	59	56	41	36	33	23	22	28	**6**
5.5	72	71	69	68	67	64	52	43	38	34	25	22	28	**5.5**
5	79	74	72	72	68	66	48	44	39	32	26	22	28	**5**
4.5	81	81	79	78	76	76	53	47	40	32	26	23	28	**4.5**
4	89	88	88	83	84	79	57	52	41	35	28	27	27	**4**
3.5	98	94	96	91	87	86	63	54	42	37	29	36	25	**3.5**
3	116	112	107	101	96	96	71	57	44	38	29	36	24	**3**
2.5	125	125	119	112	105	102	81	63	50	39	29	37	24	**2.5**
2	142	140	135	126	118	113	92	75	52	39	30	36	23	**2**
1.5	170	164	156	146	135	130	109	85	56	42	32	37	23	**1.5**
1	213	203	193	178	164	159	129	110	59	43	36	46	23	**1**
0.5	258	248	241	221	205	201	167	123	75	64	38	51	21	**0.5**
0	359	340	339	311	290	257	200	163	112	74	39	30	20	**0**
–0.5	831	806	790	651	530	491	330	190	140	62	31	25	14	**–0.5**
–1	3 836	3 422	3 058	2 603	2 302	2 364	910	588	279	78	25	25	5	**–1**
–1.5	6 689	6 105	4 989	4 306	3 764	3 356	1 551	872	381	140	34	20	5	**–1.5**
–2	7 799	6 360	4 836	4 252	4 157	3 843	1 997	897	420	194	27	10	5	**–2**
–2.5	7 050	5 782	5 300	5 082	4 355	4 169	2 258	1 057	507	220	32	21	5	**–2.5**
–3	6 965	5 944	5 209	4 693	4 230	4 151	2 498	1 328	582	224	34	16	5	**–3**
–3.5	5 444	5 006	4 531	4 191	3 751	3 778	2 482	1 410	518	204	49	21	14	**–3.5**
–4	4 934	4 337	3 864	3 639	3 392	3 095	2 382	1 320	609	172	33	30	16	**–4**
–4.5	3 901	3 738	3 489	3 459	3 139	2 972	2 182	1 324	504	158	36	31	18	**–4.5**
–5	3 409	3 267	3 022	2 971	2 850	2 698	2 019	1 317	554	145	47	36	20	**–5**
down														**down**

Table C.2 — Road distances corresponding to mean observation angles used in calculations

Passenger car V1				Large vehicle V2			
Selected road distance m	Observation angles			Selected road distance m	Observation angles		
	Left headlamp °	Right headlamp °	Mean °		Left headlamp °	Right headlamp °	Mean °
177.80	0.30002	0.19998	0.25	201.97	0.59746	0.40253	0.5
148.13	0.35714	0.24287	0.3	155.14	0.77548	0.52450	0.65
111.08	0.46846	0.33151	0.4	111.76	1.07094	0.72906	0.9
88.88	0.57601	0.42395	0.5	83.54	1.42345	0.97668	1.2
68.43	0.73045	0.56950	0.65	66.60	1.77343	1.22648	1.5
49.57	0.97055	0.82929	0.9	49.62	2.35187	1.64828	2.0
37.38	1.23371	1.16623	1.2	39.41	2.92322	2.07631	2.5
30.12	1.47447	1.52524	1.5	32.57	3.48857	2.51146	3.0
22.91	1.84152	2.15915	2.0	23.97	4.59802	3.40064	4.0

NOTE These selected road distances are used to determine illuminances corresponding to tabulated observation angles. This method results in distances that are not equally spaced in the quadrants of the distances classes. However, by tying a single distance to the selected observation angles for a vehicle class, only one set of illuminances is needed for each vehicle class.

C.3 Determination of V and H angles for the selected distances

Once the road distances are selected, the horizontal (H) and vertical (V) components of the headlamp illumination pattern shall be determined using basic trigonometry. A typical sign shall be assumed to be mounted on the left verge of a straight road, and located 5 m to the left of the centre line of the vehicle and 2.5 m above the ground. Based on this sign placement and on the position of the headlamps on the vehicle as specified in Table D.3, the V and H angles shall be determined as follows.

a) The H angle for the left beam (0.5 m left of centre) for the passenger car shall be obtained by:

$H = -\text{Arctan}\ ((5.0 - 0.5)/d)$

where:

d is the road distance.

b) The V angle for the left beam (0.65 m above ground) for the passenger car shall be obtained by:

$V = \text{Arctan}\ ((2.5 - 0.65)/(d^2 + (5.0 - 0.5)^2)^{0.5})$

where:

d is the road distance.

NOTE Table C.3 is a tabulation of V and H angles using the road distances determined to be associated with the observation angles relevant to vehicle class V1 and V2 from section C.2.

Table C.3 — Headlamp V and H angles associated with selected road distances

Passenger car V1					
Mean observation angle °	**Road distance,** d m	**Left headlamp**		**Right headlamp**	
		Horizontal angle, H °	**Vertical angle,** V °	**Horizontal angle,** H °	**Vertical angle,** V °
0.25	177.8	–1.4498	0.5959	–1.7718	0.5959
0.3	148.13	–1.7400	0.7152	–2.1264	0.7150
0.4	111.08	–2.3199	0.9534	–2.8346	0.9530
0.5	88.88	–2.8984	1.1909	–3.5410	1.1901
0.65	68.43	–3.7624	1.5453	–4.5952	1.5436
0.9	49.57	–5.1871	2.1286	–6.3313	2.1243
1.2	37.38	–6.8645	2.8131	–8.3703	2.8032
1.5	30.12	–8.4973	3.4763	–10.3484	3.4577
2.0	22.91	–11.1126	4.5305	–13.4995	4.4896
Large vehicle V2					
Mean observation angle °	**Road distance,** d m	**Left headlamp**		**Right headlamp**	
		Horizontal angle, H °	**Vertical angle,** V °	**Horizontal angle,** H °	**Vertical angle,** V °
0.5	201.97	–1.1629	0.4822	–1.6733	0.4820
0.65	155.14	–1.5138	0.6276	–2.1779	0.6274
0.9	111.76	–2.1010	0.8709	–3.0219	0.8703
1.2	83.54	–2.8097	1.1644	–4.0398	1.1629
1.5	66.60	–3.5228	1.4594	–5.0625	1.4565
2.0	49.62	–4.7235	1.9555	–6.7808	1.9485
2.5	39.41	–5.9394	2.4568	–8.5144	2.4428
3.0	32.57	–7.1748	2.9645	–10.2677	2.9401
4.0	23.97	–9.7063	3.9989	–13.8280	3.9395

C.4 Determination of the distance to the sign

The distance to the sign from the vehicle headlamps shall be used with the photometric inverse square law to find the illuminance on the sign (perpendicular to the direction of illumination from the headlamp). Separate calculations shall be conducted for the left and right headlamps, using the passenger car and large vehicle type dimensions given in Table D.3. This distance shall be calculated using the distance squared to determine the sign illuminance from candela values in the headlamp luminous intensity tables.

The distance squared shall be determined as follows (example shown is for the left headlamp):

$$(d_{sign})^2 = d^2 + (5 - 0.5)^2 + (2.5 - 0.65)^2$$

where:

d is the road distance.

Distance squared for each observation angle is tabulated in Table C.4.

Table C.4 — Sign distances corresponding to selected road distances

Passenger car V1					
		Sign distance d_{sign}		**Sign distance squared** $(d_{sign})^2$	
Observation angle °	**Road distance,** d m	**Left headlamp** m	**Right headlamp** m	**Left headlamp** m^2	**Right headlamp** m^2
0.25	177.8	177.87	177.89	31 636.5	31 646.5
0.3	148.13	148.21	148.24	21 966.2	21 976.2
0.4	111.08	111.19	111.23	12 362.4	12 372.4
0.5	88.88	89.01	89.07	7 923.3	7 933.3
0.65	68.43	68.60	68.68	4 706.3	4 716.3
0.9	49.57	49.81	49.91	2 480.9	2 490.9
1.2	37.38	37.70	37.83	1 420.9	1 430.9
1.5	30.12	30.51	30.67	930.9	940.9
2.0	22.91	23.42	23.63	548.5	558.5
Large vehicle V2					
		Sign distance d_{sign}		**Sign distance squared** $(d_{sign})^2$	
Observation angle °	**Road distance,** d m	**Left headlamp** m	**Right headlamp** m	**Left headlamp** m^2	**Right headlamp** m^2
0.5	201.97	202.02	202.06	40 811.6	40 829.6
0.65	155.14	155.20	155.26	24 088.1	24 106.1
0.9	111.76	111.85	111.93	12 510.0	12 528.0
1.2	83.54	83.66	83.77	6 998.6	7 016.6
1.5	66.60	66.75	66.88	4 455.3	4 473.3
2.0	49.62	49.82	50.00	2 481.8	2 499.8
2.5	39.41	39.66	39.89	1 572.8	1 590.8
3.0	32.57	32.87	33.14	1 080.5	1 098.5
4.0	23.97	24.38	24.74	594.3	612.3

C.5 Interpolation of the candela values

In order to find the luminous intensity in candelas at the selected V and H angles in Table C.3, linear interpolation shall be used (see example in Table C.5).

NOTE 1 Although other interpolation methods can produce smoother results, linear interpolation is easy to understand and is sufficiently accurate for this purpose.

Table C.5 — Example of interpolation method for candela values

Vertical angle, V	**Luminous intensity,** cd**, at horizontal angle,** H		
	–15°	–13.828°	–10°
4.0°	78		111
3.9395°	**79.452**	**87.5843**	**114.146**
3.5°	90		137

NOTE 2 The example given in Table C.5 shows the 4° observation angle for the right headlamp of the large vehicle. The interpolated values are in bold type. Interpolation is conducted for the V angle of 3.9395° and H angle of –13.828°. The resulting interpolated value is 87.5843 cd. (If interpolation is conducted first in the horizontal direction instead of the vertical direction, the result is the same).

NOTE 3 The interpolated candela values for the two vehicle type subclasses are given in Table C.6.

C.6 Determination of the illuminance at the sign for use in luminance calculations

In order to determine the illumination on the sign, the interpolated luminous intensity from each headlamp shall be divided by the square of the sign distance in accordance with the inverse square law. For each vehicle class, the illuminance from the left and the right headlamp shall be summed to provide a single total illuminance value as shown in Table C.6.

C.7 Correction for vehicle operating voltage

As the measured candela values for the headlamps (see Table C.1) are at 12.8 V, these shall be corrected for the typical operating voltage for a vehicle on the road, which shall be taken as 13.5 V. In order to correct for typical operating voltage, the voltage ratio to the 3.4 power method shall be used, as described in the IESNA lighting handbook [3]. The correction factor used shall be 1.19. This shall be multiplied with the sum of the left and right-hand values to obtain the final value for the luminance index calculations described in **6.7**.

NOTE The final corrected values are tabulated in the last column of Table C.6.

Table C.6 — Interpolated candela values from Table C.1: conversion to illuminance in lux, summation and final voltage correction values

Passenger car V1							
Observation angle	**Left headlamp**		**Right headlamp**		**Total**	**Corrected total**	**Rounded value**
°	cd	lx	cd	lx	lx	lx	lx
0.25	355.1126	0.011225	363.0467	0.011472	0.02270	0.02701	0.027
0.3	342.3563	0.015586	349.3504	0.015897	0.03148	0.03746	0.037
0.4	305.4302	0.024706	300.6172	0.024297	0.04900	0.05831	0.058
0.5	259.9722	0.032811	257.3949	0.032445	0.06526	0.07765	0.078
0.65	209.6509	0.044547	211.3550	0.044813	0.08936	0.10634	0.106
0.9	188.1692	0.075848	175.6326	0.070511	0.14636	0.17417	0.174
1.2	148.8225	0.104735	161.3553	0.112762	0.21750	0.25882	0.259
1.5	148.9716	0.160032	134.9684	0.143448	0.30348	0.36114	0.361
2.0	81.8215	0.149162	76.8363	0.137566	0.28673	0.34121	0.341
Large vehicle V2							
Observation angle	**Left headlamp**		**Right headlamp**		**Total**	**Corrected total**	**Rounded value**
°	cd	lx	cd	lx	lx	lx	lx
0.5	376.1872	0.009218	389.7553	0.009546	0.01876	0.02233	0.022
0.65	351.4309	0.014589	366.4138	0.015200	0.02979	0.03545	0.035
0.9	320.4558	0.025616	321.3939	0.025654	0.05127	0.06101	0.061
1.2	265.5915	0.037949	259.9793	0.037052	0.07500	0.08925	0.089
1.5	217.1627	0.048743	222.0933	0.049649	0.09839	0.11709	0.117
2.0	195.4411	0.078748	180.6210	0.072253	0.15100	0.17969	0.180
2.5	166.1836	0.105658	168.3925	0.105851	0.21151	0.25170	0.252
3.0	146.3951	0.135488	151.8001	0.138188	0.27368	0.32567	0.326
4.0	113.7024	0.191334	87.5843	0.143051	0.33438	0.39792	0.398

Annex D (informative) Selection of observation angles

D.1 General

This annex gives the method used to select the observation angle categories associated with the viewing distance ranges and vehicle types, as presented in Table D.6.

D.2 Viewing distance subclasses

Because a driver sees a sign over a range of distances, the luminance available to the driver over the range of distances given in Table D.1 is used for the purposes of photometric rating. The selection of the observation angles is intended to represent viewing distances within the four distance subclasses.

Table D.1 — Distance subclasses

Distance subclass	Distance range m
Long (D1)	200 – 50
Medium (D2)	120 – 40
Short (D3)	90 – 30
Close (D4)	50 – 20

For each viewing distance range, the furthest distance represents the driver's first chance to read the sign legend (based on legend size). The closest distance is the driver's last chance to see the sign before the sign is out of their field of view. Within this possible viewing range, the driver visually fixes on the sign several times. Usually the driver attempts to read the sign message at a longer distance and then fixes a second time to confirm the message. These fixations can occur more or less randomly within the possible viewing range.

In order to represent sign performance within each viewing range, four sampling distances are chosen by dividing the total viewing range into quarters and then finding the central point in each quarter. These four central distance points are the sampling distances to be used in the observation angle calculations. This process results in the sampling distances shown in Table D.2.

Table D.2 — Sampling distances

Distance	Sampling distance, m			
subclass	QI	QII	QIII	QIV
Long	181.25	143.75	106.25	68.75
Medium	110.00	90.00	70.00	50.00
Short	82.50	67.50	52.50	37.50
Close	45.25	38.75	31.25	23.75

D.3 Vehicle types

In selecting observation angles for testing, only the passenger car and large vehicle (lorry) are considered. Other vehicles are assumed to be less significant.

NOTE 1 The proportion of lorries at night can exceed 60 % on some routes, although it is less than 10 % on others.

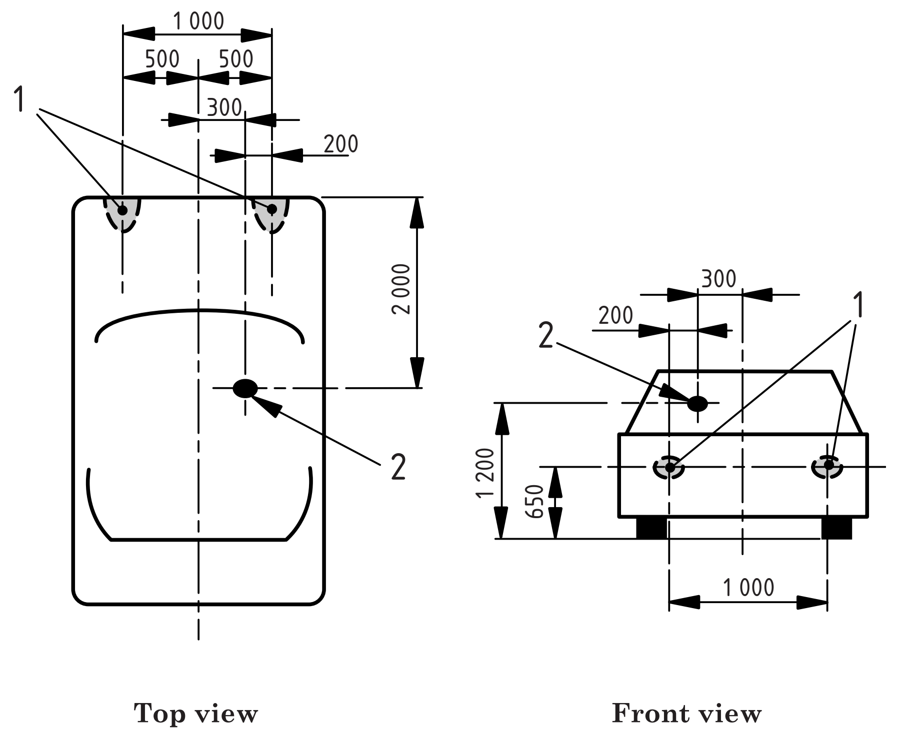
NOTE 2 As motorcyclists are less frequent night drivers and see signs at smaller observation angles, which typically results in higher luminance, they are not considered in the calculations. Vans and utility vehicles fall between the two principal vehicle types.

NOTE 3 The luminance performance achieved differs substantially between large vehicles (e.g. buses and lorries) and passenger cars because of the different relationships of the driver to the headlamp position, resulting in different observation angles at a given distance. This influences the selection of the observation angle appropriate for the driver in the various driving distance classes. The dimensions assumed for the two vehicle types are set out in Table D.3 and further detailed in Figure D.1 and Figure D.2.

Table D.3 — Vehicle type

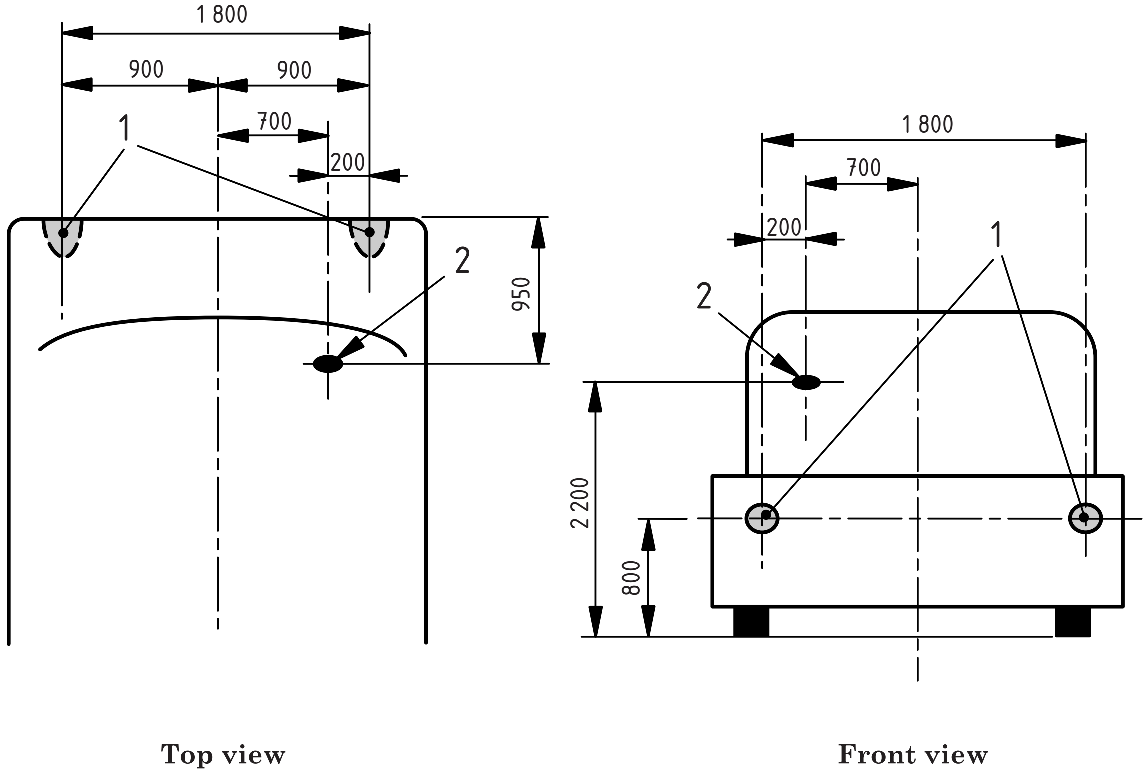
Vehicle type	**Vehicle dimensions,** m				
	h_1	h_2	s_1	s_2	s_3
Passenger car, V1	0.65	1.20	1.00	0.30	2.00
Large vehicle, V2	0.80	2.20	1.80	0.70	0.95

h_1: height of headlamps above road
h_2: height of driver's eyes above road
s_1: distance between headlamps
s_2: distance of eyes to the right of the vehicle centreline
s_3: distance of eyes behind headlamps



Key
1 = Headlamps
2 = Driver's eye

Figure D.1 — UK passsenger car



Key
1 = Headlamps
2 = Driver's eye

Figure D.2 — UK large vehicle

D.4 Sign location

The sign location has an influence on the observation angle but this influence is not as important as that of viewing distance and vehicle type. The most frequently occurring signs are verge-mounted. Therefore, a typical left shoulder sign location is used (vehicle centred in left hand driving lane) for the calculation of observation angles associated with each viewing distance range. The dimensions used are illustrated in Figure D.3, showing the passenger car as viewed from behind. Only a straight road is considered.

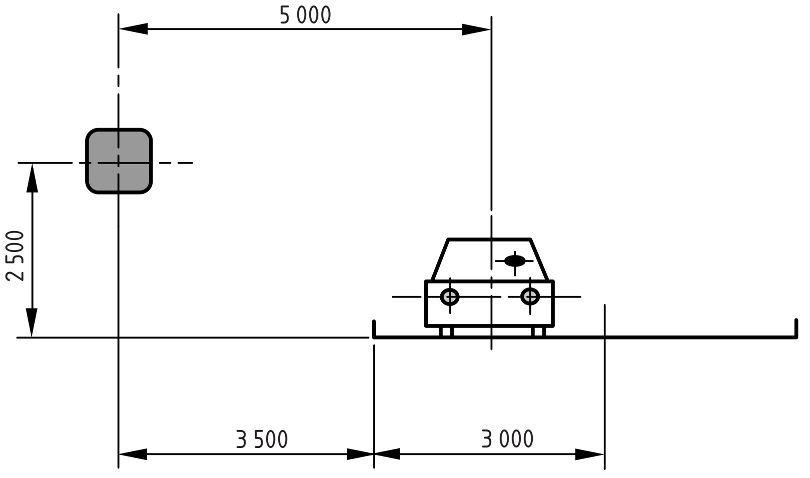


Figure D.3 — Sign location

D.5 Observation angle calculations

In order to determine the appropriate observation angle associated with the central sampling distance for each quarter of each viewing distance range given in Table D.2, a viewing scenario calculation is completed using the method specified in CIE 54.2. Scenario calculations are completed for a passenger car and a large vehicle. For each vehicle type, the mean of the observation angles associated with the left and right headlamps is determined. The results of these calculations are shown in Table D.4.

Table D.4 — Calculated observation angle, α

Distance subclass	Quarter sample (m)	Passenger car			Large vehicle		
		Left	Right	Mean	Left	Right	Mean
Long	181.25	0.295	0.196	0.246	0.665	0.449	0.557
	143.75	0.367	0.251	0.309	0.836	0.566	0.701
	106.25	0.488	0.348	0.418	1.125	0.767	0.946
	68.75	0.727	0.566	0.646	1.720	1.188	1.454
Medium	110	0.473	0.335	0.404	1.088	0.741	0.914
	90	0.569	0.418	0.494	1.324	0.906	1.073
	70	0.716	0.554	0.635	1.690	1.167	1.429
	50	0.963	0.821	0.892	2.335	1.636	1.986
Short	82.5	0.617	0.461	0.539	1.441	0.989	1.215
	67.5	0.739	0.578	0.658	1.751	1.210	1.480
	52.5	0.923	0.775	0.849	2.229	1.558	1.894
	37.5	1.230	1.162	1.196	3.062	2.182	2.622
Close	46.25	1.030	0.901	0.966	2.514	1.769	2.142
	38.75	1.197	1.116	1.156	2.970	2.112	2.541
	31.25	1.431	1.456	1.444	3.623	2.617	3.120
	23.75	2.062	1.788	1.925	4.635	3.431	4.033

D.6 Selected observation angles

For the passenger car and large vehicle types, twelve observation angle measurement points were selected which closely relate to the calculated mean angles shown in Table D.4.

These observation angle measurement points are grouped by distance and vehicle type, and shown in Table D.5 and Table D.6.

Table D.5 — Selected observation angles

Distance subclass	Quarter distance m	Passenger car		Large vehicle	
		Calculated mean, α	Selected test angle	Calculated mean, α	Selected test angle
Long	181.25	0.246	0.25	0.557	0.50
	143.75	0.309	0.30	0.701	0.65
	106.25	0.418	0.40	0.946	0.90
	68.75	0.646	0.65	1.454	1.50
Medium	110	0.404	0.40	0.914	0.90
	90	0.494	0.50	1.073	1.20
	70	0.635	0.65	1.429	1.50
	50	0.892	0.90	1.986	2.00
Short	82.5	0.539	0.50	1.215	1.20
	67.5	0.658	0.65	1.480	1.50
	52.5	0.849	0.90	1.894	2.00
	37.5	1.196	1.20	2.622	2.50
Close	46.25	0.966	0.90	2.142	2.00
	38.75	1.156	1.20	2.541	2.50
	31.25	1.444	1.50	3.120	3.00
	23.75	1.925	2.00	4.033	4.00

Table D.6 — Observation angle grouping by distance subclass and vehicle type

Observation angle, α	D1 (long)		D2 (medium)		D3 (short)		D4 (close)	
	Car	Large	Car	Large	Car	Large	Car	Large
0.25	●							
0.30	●							
0.40	●		●					
0.50		●	●		●			
0.65	●	●	●		●			
0.90		●	●	●	●		●	
1.20				●	●	●	●	
1.50		●		●		●	●	
2.00				●		●	●	●
2.50						●		●
3.00								●
4.00								●

NOTE The groups of observation angles are intended to give approximately equal steps over each distance range. The groupings are based on a typical left hand shoulder-mounted sign location and use the mean of the observation angles for the left and the right headlamp. The sign position is not critical for average observation angle values.

Annex E (informative) Example of luminance index calculations

E.1 General

This annex provides an example of the calculation of luminance index used in the production of photometric ratings (see Clause **6**), showing the reduction of the base photometric measurements to produce an effective luminance index.

The example calculation in **E.2** to **E.7** is for a single photometric procedure with a single datum axis designation. To obtain complete photometric ratings, the calculation has to be carried out for both new sheeting material and material after accelerated weathering testing has been completed. The measurement of RA and the calculation are therefore conducted at least twice. If sheeting material is to be qualified for use with two mounting directions (e.g. with the datum mark vertical or horizontal on a sign) a second set of two measurements and calculations is performed with the second datum axis designated appropriately. This results in separate ratings for separate datum axes.

E.2 Measurements at designated measurement angles

432 designated combinations of measurement angles are described in Table 8 and Table 9. An example of measurement results from a white microprismatic material test sample is shown in Tables E.1 to Table E.12.

Table E.1 — Values of R_A for observation angle $\alpha = 0.25°$

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
β	ε	−90°	−75°	0°	+75°	+90°
5°	−45°			385		
	0°			458		
	+45°			369		
15°	−45°	313		401		327
	0°	372		404		389
	+45°	322		366		321
30°	−45°	171	213		163	170
	0°	248	172		143	261
	+45°	179	195		187	154
40°	−45°	119	151		96.7	108
	0°	53.9	118		87.6	56.2
	+45°	124	134		132	98.0

Table E.2 — Values of R_A for observation angle α = 0.30°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
β	ε	−90°	−75°	0°	+75°	+90°
5°	−45°			433		
	0°			429		
	+45°			424		
15°	−45°	354		394		361
	0°	437		392		445
	+45°	343		406		337
30°	−45°	191	180		171	177
	0°	297	196		150	303
	+45°	194	218		168	159
40°	−45°	136	125		109	113
	0°	65.9	135		98.0	66.3
	+45°	141	147		119	106

Table E.3 — Values of R_A for observation angle α = 0.40°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
β	ε	−90°	−75°	0°	+75°	+90°
5°	−45°			417		
	0°			390		
	+45°			429		
15°	−45°	376		336		367
	0°	354		380		350
	+45°	367		352		356
30°	−45°	194	156		169	161
	0°	245	185		154	244
	+45°	200	195		152	167
40°	−45°	130	104		114	109
	0°	55.2	119		104	54.2
	+45°	138	125		106	114

Table E.4 — Values of R_A for observation angle α = 0.50°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
		−90°	−75°	0°	+75°	+90°
β	ε					
5°	−45°			316		
	0°			323		
	+45°			305		
15°	−45°	286		312		298
	0°	266		315		270
	+45°	293		254		309
30°	−45°	159	140		159	156
	0°	194	146		146	198
	+45°	155	159		137	161
40°	−45°	105	98.6		93.4	105
	0°	46.7	100		92.7	47.4
	+45°	101	103		98.9	102

Table E.5 — Values of R_A for observation angle α = 0.65°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
		−90°	−75°	0°	+75°	+90°
β	ε					
5°	−45°			237		
	0°			243		
	+45°			218		
15°	−45°	205		208		234
	0°	213		226		216
	+45°	200		184		227
30°	−45°	112	105		105	127
	0°	142	105		102	142
	+45°	101	113		102	116
40°	−45°	72.6	73.7		63.5	71.3
	0°	33.4	66.2		60.2	32.5
	+45°	73.2	67.0		75.1	72.7

Table E.6 — Values of R_A for observation angle α = 0.90°

ω_s		Coefficient of retroreflection R_A (cd·lx^{-1}·m^{-2})				
		−90°	**−75°**	**0°**	**+75°**	**+90°**
β	**ε**					
5°	**−45°**			120		
	0°			137		
	+45°			125		
15°	**−45°**	106		105		114
	0°	110		119		111
	+45°	120		107		118
30°	**−45°**	53.7	59.3		48.0	68.0
	0°	74.0	48.7		52.4	76.3
	+45°	61.4	46.0		65.3	68.2
40°	**−45°**	34.1	35.5		28.4	37.6
	0°	18.0	27.1		28.8	17.5
	+45°	38.7	21.7		41.1	41.7

Table E.7 — Values of R_A for observation angle α = 1.20°

ω_s		Coefficient of retroreflection R_A (cd·lx^{-1}·m^{-2})				
		−90°	**−75°**	**0°**	**+75°**	**+90°**
β	**ε**					
5°	**−45°**			46.4		
	0°			63.6		
	+45°			57.6		
15°	**−45°**	45.4		47.4		50.5
	0°	62.7		51.1		64.2
	+45°	55.2		57.1		50.9
30°	**−45°**	21.7	31.9		23.3	25.9
	0°	42.0	21.6		27.2	42.6
	+45°	31.9	17.5		37.4	26.9
40°	**−45°**	16.3	20.0		13.3	17.3
	0°	8.50	12.3		15.7	8.56
	+45°	21.6	8.35		25.8	21.8

Table E.8 — Values of R_A for observation angle α = 1.50°

ω_s		Coefficient of retroreflection R_A (cd·lx^{-1}·m^{-2})				
		–90°	**–75°**	**0°**	**+75°**	**+90°**
β	**ε**					
5°	**–45°**			29.4		
	0°			31.5		
	+45°			32.6		
15°	**–45°**	26.4		22.5		29.9
	0°	29.4		27.4		27.5
	+45°	31.8		27.4		32.4
30°	**–45°**	12.3	17.7		10.2	16.9
	0°	19.8	10.6		13.6	18.5
	+45°	15.2	8.10		22.1	16.6
40°	**–45°**	7.17	11.3		6.28	7.98
	0°	5.04	6.03		8.00	4.37
	+45°	8.14	3.72		15.3	9.69

Table E.9 — Values of R_A for observation angle α = 2.00°

ω_s		Coefficient of retroreflection R_A (cd·lx^{-1}·m^{-2})				
		–90°	**–75°**	**0°**	**+75°**	**+90°**
β	**ε**					
5°	**–45°**			11.1		
	0°			11.1		
	+45°			14.2		
15°	**–45°**	9.95		10.2		11.5
	0°	11.7		9.00		11.4
	+45°	13.6		13.0		11.9
30°	**–45°**	4.40	6.35		3.42	5.44
	0°	8.02	3.91		6.06	7.48
	+45°	7.24	3.44		7.63	5.63
40°	**–45°**	2.95	4.33		2.21	3.15
	0°	2.19	2.19		3.16	1.80
	+45°	5.46	1.73		5.07	4.18

Table E.10 — Values of R_A for observation angle α = 2.50°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
		−90°	−75°	0°	+75°	+90°
β	ε					
5°	**−45°**			5.01		
	0°			5.09		
	+45°			6.38		
15°	**−45°**	4.44		4.53		5.33
	0°	5.31		4.70		4.56
	+45°	5.69		5.62		6.24
30°	**−45°**	2.51	3.30		1.59	2.37
	0°	3.47	2.07		2.38	3.28
	+45°	3.40	1.62		3.20	2.50
40°	**−45°**	1.79	2.31		1.21	1.64
	0°	1.20	1.26		1.57	0.85
	+45°	2.60	0.93		2.37	1.81

Table E.11 — Values of R_A for observation angle α = 3.00°

ω_s		Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$)				
		−90°	−75°	0°	+75°	+90°
β	ε					
5°	**−45°**			3.16		
	0°			2.79		
	+45°			3.51		
15°	**−45°**	2.69		2.78		3.12
	0°	2.64		2.60		2.55
	+45°	3.70		2.71		3.39
30°	**−45°**	1.44	1.87		1.08	1.45
	0°	1.55	0.93		1.42	1.81
	+45°	2.06	0.94		1.58	1.31
40°	**−45°**	1.08	1.30		0.80	1.08
	0°	0.56	0.56		0.99	0.49
	+45°	1.55	0.53		1.08	0.87

Table E.12 — Values of R_A for observation angle α = 4.00°

ωs		Coefficient of retroreflection R_A (cd·lx^{-1}·m^{-2})				
		–90°	–75°	0°	+75°	+90°
β	ε					
5°	–45°			1.95		
	0°			1.55		
	+45°			1.68		
15°	–45°	1.47		1.57		1.30
	0°	1.33		1.09		1.33
	+45°	1.40		1.27		1.42
30°	–45°	0.78	0.97		0.48	0.70
	0°	0.84	0.48		0.82	1.07
	+45°	1.06	0.52		0.60	0.45
40°	–45°	0.59	0.67		0.38	0.50
	0°	0.33	0.34		0.62	0.30
	+45°	0.74	0.31		0.44	0.33

E.3 Reduction of rotation angles (see Table E.13)

The mean rotation angles values calculated in accordance with **6.4** are shown in Table E.13. Note that in this and in all subsequent tables, the values shown are rounded to two or three significant figures, but each pre-rounded value is used in further calculations.

Table E.13 — R_A values reduced for mean of three epsilon (ε) values at –45°, 0° and +45°

Observation angle, α	Entrance angle, β	Orientation angle				
		ω_s = –90°	ω_s = –75°	ω_s = 0°	ω_s = +75°	ω_s = +90°
0.25°	5°			404		
	15°	336		390		346
	30°	199	193		164	195
	40°	99.0	134		105	87.4
0.30°	5°			429		
	15°	378		397		381
	30°	227	198		163	213
	40°	114	136		109	95.1
0.40°	5°			412		
	15°	366		356		358
	30°	213	179		158	191
	40°	108	116		108	92.4
0.50°	5°			315		
	15°	282		294		292
	30°	169	148		147	172
	40°	84.2	101		95.0	84.8
0.65°	5°			233		
	15°	206		206		226
	30°	118	108		103	128
	40°	59.7	69.0		66.3	58.8

Table E.13 — R_A values reduced for mean of three epsilon (ε) values at –45°, 0° and +45° (*continued*)

Observation angle, α	Entrance angle, β	Orientation angle				
		ω_s = –90°	ω_s = –75°	ω_s = 0°	ω_s = +75°	ω_s = +90°
0.90°	5°			127		
	15°	112		110		114
	30°	63.0	51.3		55.2	70.8
	40°	30.3	28.1		32.8	32.3
1.20°	5°			55.9		
	15°	54.4		51.9		55.2
	30°	31.9	23.7		29.3	31.8
	40°	15.5	13.6		18.3	15.9
1.50°	5°			31.2		
	15°	29.2		25.8		29.9
	30°	15.8	12.1		15.3	17.3
	40°	6.78	7.02		9.86	7.35
2.00°	5°			12.1		
	15°	11.8		10.7		11.6
	30°	6.55	4.57		5.70	6.18
	40°	3.53	2.75		3.48	3.04
2.50°	5°			5.49		
	15°	5.15		4.95		5.38
	30°	3.13	2.33		2.39	2.72
	40°	1.86	1.50		1.72	1.43
3.00°	5°			3.15		
	15°	3.01		2.70		3.02
	30°	1.68	1.25		1.36	1.52
	40°	1.06	0.80		0.96	0.81
4.00°	5°			1.73		
	15°	1.40		1.31		1.35
	30°	0.89	0.66		0.63	0.74
	40°	0.55	0.44		0.48	0.38

E.4 Reduction of orientation angles

The results of taking the minimum values for orientation for the test sample in accordance with **6.5** are shown in Table E.14.

Table E.14 — R_A values reduced to lowest value of R_A at the relevant orientation angles (ω_s)

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°	404	429	412	315	233	127	55.9	31.2	12.1	5.49	3.15	1.73
15°	336	378	356	282	206	110	51.9	25.8	10.7	4.95	2.70	1.31
30°	164	163	158	147	103	51.3	23.7	12.1	4.57	2.33	1.25	0.63
40°	87.4	95.1	92.4	84.2	58.8	28.1	13.6	6.78	2.75	1.43	0.80	0.38

E.5 Conversion to R_L values (see **6.6**)

The results of calculating the coefficient of retroreflected luminance, R_L, for the sample tested from the R_A values in Table E.14 are shown in Table E.15.

Table E.15 — R_L values derived from R_A values in Table E.14

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°	406	430	414	316	234	128	56.1	31.3	12.2	5.51	3.17	1.73
15°	348	391	369	292	213	114	53.7	26.7	11.1	5.12	2.79	1.36
30°	190	188	183	170	119	59.3	27.3	14.0	5.27	2.69	1.44	0.73
40°	114	124	121	110	76.8	36.7	17.7	8.86	3.59	1.87	1.04	0.49

The R_L values are then reduced by angularity subclass (see Table 7 and Table E.16). The lowest R_L value for each subclass is then used in subsequent luminance calculations.

Table E.16 — R_L values reduced for entrance angularity subclasses

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	348	391	369	292	213	114	53.7	26.7	11.1	5.12	2.79	1.36
A2 medium	190	188	183	170	119	59.3	27.3	14.0	5.27	2.69	1.44	0.73
A3 wide	114	124	121	110	76.8	36.7	17.7	8.86	3.59	1.87	1.04	0.49

E.6 Luminance calculations (see **6.7**)

For each vehicle type, V1 passenger car and V2 large vehicle, an illuminance value, E, from Table C.6 is assigned to each of the nine applicable observation angles. The luminance, L, is calculated as the product of this illuminance, E, and the R_L taken from Table E.16.

Table E.17 V1 — Luminance values determined from illuminance and R_L values for vehicle type V1

Illuminance	Observation angle, α								
	0.25	0.30	0.40	0.50	0.65	0.90	1.20	1.50	2.00
Illuminance E	0.027	0.037	0.058	0.078	0.106	0.174	0.259	0.361	0.341
A1 R_L	348	391	369	292	213	114	53.7	26.7	11.1
A1 Luminance L	9.38	14.5	21.4	22.7	22.6	19.9	13.9	9.63	3.79
A2 R_L	190	188	183	170	119	59.3	27.3	14.0	5.27
A2 Luminance L	5.12	6.96	10.6	13.3	12.6	10.3	7.08	5.06	1.80
A3 R_L	114	124	121	110	76.8	36.7	17.7	8.86	3.59
A3 Luminance L	3.08	4.59	7.00	8.58	8.14	6.38	4.58	3.20	1.22

Table E.17 V2 — Luminance values determined from illuminance and R_L values for vehicle type V2

Illuminance	Observation angle, α								
	0.50	0.65	0.90	1.20	1.50	2.00	2.50	3.00	4.00
Illuminance	0.022	0.035	0.061	0.089	0.117	0.18	0.252	0.326	0.398
A1 RL	292	213	114	53.7	26.7	11.1	5.12	2.79	1.36
A1 Luminance L	6.42	7.46	6.97	4.78	3.12	2.00	1.29	0.91	0.54
A2 RL	170	119	59.3	27.3	14.0	5.27	2.69	1.44	0.73
A2 Luminance L	3.74	4.16	3.62	2.43	1.64	0.95	0.68	0.47	0.29
A3 RL	110	76.8	36.7	17.7	8.86	3.59	1.87	1.04	0.49
A3 Luminance L	2.42	2.69	2.24	1.57	1.04	0.65	0.47	0.34	0.20

E.7 Luminance index calculations (see **6.7**)

Calculations have to be done for both Luminance Index A and Luminance Index B for each of the three entrance angularity classes (A1, A2, A3) for each of the two vehicle types (V1 and V2). The results of these calculations are shown for the sample tested in the following twelve tables. The relevant observation angles are taken from Table D.6.

Table E.18A-A1 — Luminance Index A (for directional signs) calculations for V1 passenger car for entrance angularity subclass A1

Observation angle α	Illuminance E lx	Luminance ($cd \cdot m^{-2}$)											
		Distance subclass											
		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	9.38	10	1.07									
0.30	0.037	14.5	4	0.28									
0.40	0.058	21.4	3	0.14	21.4	10	0.47						
0.50	0.078				22.7	4	0.18	22.7	10	0.44			
0.65	0.106	22.6	3	0.13	22.6	3	0.13	22.6	4	0.18			
0.90	0.174				19.9	3	0.15	19.9	3	0.15	19.9	10	0.50
1.20	0.259							13.9	3	0.22	13.9	4	0.29
1.50	0.361										9.63	3	0.31
2.00	0.341										3.79	3	0.79
V1 Uncorrected Luminance Index A (see NOTE 2)		2.48			4.31			4.07			2.11		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index A (see NOTE 3)		2.48			4.31			4.07			2.11		

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.

Table E.18A-A2 — Luminance Index A (for directional signs) calculations for V1 passenger car for entrance angularity subclass A2

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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	5.12	10	1.95									
0.30	0.037	6.96	4	0.57									
0.40	0.058	10.6	3	0.28	10.6	10	0.94						
0.50	0.078				13.3	4	0.30	13.3	10	0.75			
0.65	0.106	12.6	3	0.24	12.6	3	0.24	12.6	4	0.32			
0.90	0.174				10.3	3	0.29	10.3	3	0.29	10.3	10	0.97
1.20	0.259							7.08	3	0.42	7.08	4	0.57
1.50	0.361										5.06	3	0.59
2.00	0.341										1.80	3	1.67
V1 Uncorrected Luminance Index A (see NOTE 2)		1.31			2.26			2.24			1.05		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index A (see NOTE 3)		1.31			2.26			2.24			1.05		

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.

Table E.18A-A3 — Luminance Index A (for directional signs) calculations for V1 passenger car for entrance angularity subclass A3

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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	3.08	10	3.25									
0.30	0.037	4.59	4	0.87									
0.40	0.058	7.00	3	0.43	7.00	10	1.43						
0.50	0.078				8.58	4	0.47	8.58	10	1.17			
0.65	0.106	8.14	3	0.37	8.14	3	0.37	8.14	4	0.49			
0.90	0.174				6.38	3	0.47	6.38	3	0.47	6.38	10	1.57
1.20	0.259							4.58	3	0.65	4.58	4	0.87
1.50	0.361										3.20	3	0.94
2.00	0.341										1.22	3	2.45
V1 Uncorrected Luminance Index A (see NOTE 2)		0.81			1.46			1.44			0.69		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index A (see NOTE 3)		0.81			1.46			1.44			0.69		

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.

Table E.18B-A1 — Luminance Index B (for warning and regulatory signs) calculations for V1 passenger car for entrance angularity subclass A1

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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	9.38	3	0.32									
0.30	0.037	14.5	3	0.21									
0.40	0.058	21.4	3	0.14	21.4	3	0.14						
0.50	0.078				22.7	3	0.13	22.7	3	0.13			
0.65	0.106	22.6	3	0.13	22.6	3	0.13	22.6	3	0.13			
0.90	0.174				19.9	3	0.15	19.9	3	0.15	19.9	3	0.15
1.20	0.259							13.9	3	0.22	13.9	3	0.22
1.50	0.361										9.63	3	0.31
2.00	0.341										3.79	3	0.79
V1 Uncorrected Luminance Index B (see NOTE 2)		5.00			7.20			6.34			2.72		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index B (see NOTE 3)		5.00			7.20			6.34			2.72		

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.

Table E.18B-A2 — Luminance Index B (for warning and regulatory signs) calculations for V1 passenger car for entrance angularity subclass A2

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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	5.12	3	0.59									
0.30	0.037	6.96	3	0.43									
0.40	0.058	10.6	3	0.28	10.6	3	0.28						
0.50	0.078				13.3	3	0.23	13.3	3	0.23			
0.65	0.106	12.6	3	0.24	12.6	3	0.24	12.6	3	0.24			
0.90	0.174				10.3	3	0.29	10.3	3	0.29	10.3	3	0.29
1.20	0.259							7.08	3	0.42	7.08	3	0.42
1.50	0.361										5.06	3	0.59
2.00	0.341										1.80	3	1.67
V1 Uncorrected Luminance Index B (see NOTE 2)		2.60			3.85			3.39			1.34		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index B (see NOTE 3)		2.60			3.85			3.39			1.34		

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.

Table E.18B-A3 — Luminance Index B (for warning and regulatory signs) calculations for V1 passenger car for entrance angularity subclass A3

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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	3.08	3	0.97									
0.30	0.037	4.59	3	0.65									
0.40	0.058	7	3	0.43	7	3	0.43						
0.50	0.078				8.58	3	0.35	8.58	3	0.35			
0.65	0.106	8.14	3	0.37	8.14	3	0.37	8.14	3	0.37			
0.90	0.174				6.38	3	0.47	6.38	3	0.47	6.38	3	0.47
1.20	0.259							4.58	3	0.65	4.58	3	0.65
1.50	0.361										3.20	3	0.94
2.00	0.341										1.22	3	2.45
V1 Uncorrected Luminance Index B (see NOTE 2)		1.65			2.47			2.17			0.89		
Colour factor (see Table 11)		1			1			1			1		
V1 Luminance Index B (see NOTE 3)		1.65			2.47			2.17			0.89		

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.

Table E.19A-A1 — Luminance Index A (for directional signs) calculations for V2 large vehicle for entrance angularity subclass A1

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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)
0.50	0.022	6.42	10	1.56									
0.65	0.035	7.46	4	0.54									
0.90	0.061	6.97	3	0.43	6.97	10	1.44						
1.20	0.089				4.78	4	0.84	4.78	10	2.09			
1.50	0.117	3.12	3	0.96	3.12	3	0.96	3.12	4	1.28			
2.00	0.180				2.00	3	1.50	2.00	3	1.50	2.00	10	5.00
2.50	0.252							1.29	3	2.32	1.29	4	3.10
3.00	0.326										0.91	3	3.30
4.00	0.398										0.54	3	5.56
V2 Uncorrected Luminance Index A (see NOTE 2)		1.15			0.85			0.56			0.24		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index A (see NOTE 3)		1.15			0.85			0.56			0.24		

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.

Table E.19A-A2 — Luminance Index A (for directional signs) calculations for V2 large vehicle for entrance angularity subclass A2

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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)
0.50	0.022	3.74	10	2.67									
0.65	0.035	4.16	4	0.96									
0.90	0.061	3.62	3	0.83	3.62	10	2.77						
1.20	0.089				2.43	4	1.64	2.43	10	4.11			
1.50	0.117	1.64	3	1.83	1.64	3	1.83	1.64	4	2.44			
2.00	0.180				0.95	3	3.16	0.95	3	3.16	0.95	10	10.5
2.50	0.252							0.68	3	4.42	0.68	4	5.90
3.00	0.326										0.47	3	6.39
4.00	0.398										0.29	3	10.3
V2 Uncorrected Luminance Index A (see NOTE 2)		0.64			0.43			0.28			0.12		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index A (see NOTE 3)		0.64			0.43			0.28			0.12		

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.

Table E.19A-A3 — Luminance Index A (for directional signs) calculations for V2 large vehicle for entrance angularity subclass A3

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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)
0.50	0.022	2.42	10	4.13									
0.65	0.035	2.69	4	1.49									
0.90	0.061	2.24	3	1.34	2.24	10	4.47						
1.20	0.089				1.57	4	2.54	1.57	10	6.35			
1.50	0.117	1.04	3	2.90	1.04	3	2.90	1.04	4	3.86			
2.00	0.180				0.65	3	4.64	0.65	3	4.64	0.65	10	15.5
2.50	0.252							0.47	3	6.36	0.47	4	8.48
3.00	0.326										0.34	3	8.85
4.00	0.398										0.20	3	15.3
V2 Uncorrected Luminance Index A (see NOTE 2)		0.41			0.27			0.19			0.08		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index A (see NOTE 3)		0.41			0.27			0.19			0.08		

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.

Table E.19B-A1 — Luminance Index B (for warning and regulatory signs) calculations for V2 large vehicle for entrance angularity subclass A1

Observation angle α	**Illuminance E** lx	**Luminance** (cd·m^{-2})											
		Distance subclass											
		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)
0.50	0.022	6.42	3	0.47									
0.65	0.035	7.46	3	0.40									
0.90	0.061	6.97	3	0.43	6.97	3	0.43						
1.20	0.089				4.78	3	0.63	4.78	3	0.63			
1.50	0.117	3.12	3	0.96	3.12	3	0.96	3.12	3	0.96			
2.00	0.180				2.00	3	1.50	2.00	3	1.50	2.00	3	1.50
2.50	0.252							1.29	3	2.32	1.29	3	2.32
3.00	0.326										0.91	3	3.30
4.00	0.398										0.54	3	5.56
V2 Uncorrected Luminance Index B (see NOTE 2)		1.77			1.14			0.74			0.32		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index B (see NOTE 3)		1.77			1.14			0.74			0.32		

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.

Table E.19B-A2 — Luminance Index B (for warning and regulatory signs) calculations for V2 large vehicle for entrance angularity subclass A2

Observation angle α	**Illuminance E** lx	**Luminance** ($cd \cdot m^{-2}$)											
		Distance subclass											
		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)
0.50	0.022	3.74	3	0.80									
0.65	0.035	4.16	3	0.72									
0.90	0.061	3.62	3	0.83	3.62	3	0.83						
1.20	0.089				2.43	3	1.23	2.43	3	1.23			
1.50	0.117	1.64	3	1.83	1.64	3	1.83	1.64	3	1.83			
2.00	0.180				0.95	3	3.16	0.95	3	3.16	0.95	3	3.16
2.50	0.252							0.68	3	4.42	0.68	3	4.42
3.00	0.326										0.47	3	6.39
4.00	0.398										0.29	3	10.3
V2 Uncorrected Luminance Index B (see NOTE 2)		0.96			0.57			0.38			0.16		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index B (see NOTE 3)		0.96			0.57			0.38			0.16		

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.

Table E.19B-A3 — Luminance Index B (for warning and regulatory signs) calculations for V2 large vehicle for entrance angularity subclass A3

Observation angle α	Illuminance E lx	Luminance (cd·m^{-2})											
		Distance subclass											
		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)
0.50	0.022	2.42	3	1.24									
0.65	0.035	2.69	3	1.12									
0.90	0.061	2.24	3	1.34	2.24	3	1.34						
1.20	0.089				1.57	3	1.91	1.57	3	1.91			
1.50	0.117	1.04	3	2.90	1.04	3	2.90	1.04	3	2.90			
2.00	0.180				0.65	3	4.64	0.65	3	4.64	0.65	3	4.64
2.50	0.252							0.47	3	6.36	0.47	3	6.36
3.00	0.326										0.34	3	8.85
4.00	0.398										0.20	3	15.3
V2 Uncorrected Luminance Index B (see NOTE 2)		0.61			0.37			0.25			0.11		
Colour factor (see Table 11)		1			1			1			1		
V2 Luminance Index B (see NOTE 3)		0.61			0.37			0.25			0.11		

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.

E.8 Luminance index (see 6.8)

The results of the calculations of effective luminance are entered into Table E.20A and Table E.20B for the sample retroreflection data, as shown below.

Table E.20A — Luminance Index A values by subclass

Entrance angularity subclass		A1 narrow 5°, 15°		A2 medium 5°, 15°, 30°		A3 wide 5°, 15°, 30°, 40°	
Vehicle type		Passenger car	Large vehicle	Passenger car	Large vehicle	Passenger car	Large vehicle
Distance subclass	D1 long	2.48	1.15	1.31	0.64	0.81	0.41
	D2 medium	4.31	0.85	2.26	0.43	1.46	0.27
	D3 short	4.07	0.56	2.24	0.28	1.44	0.19
	D4 close	2.11	0.24	1.05	0.12	0.69	0.08

Table E.20B — Luminance Index B values by subclass

Entrance angularity Subclass		A1 narrow 5º, 15º		A2 medium 5º, 15º, 30º		A3 wide 5º, 15º, 30º, 40º	
Vehicle type		Passenger car	Large vehicle	Passenger car	Large vehicle	Passenger car	Large vehicle
Distance subclass	D1 long	5.00	1.77	2.60	0.96	1.65	0.61
	D2 medium	7.20	1.14	3.85	0.57	2.47	0.37
	D3 short	6.34	0.74	3.39	0.38	2.17	0.25
	D4 close	2.72	0.32	1.34	0.16	0.89	0.11

E.9 Measurements before and after weathering

Table E.20A and Table E.20B are produced before and after weathering. The final luminance index report takes the lower value from each cell of the before and after weathering tables.

Annex F (informative) Calculation of the luminance index

The luminance of a sign made from retroreflective sheeting changes as it is illuminated and viewed from an approaching vehicle. This is due to the sheeting's coefficient of retroreflection (R_A) varying with the observation angle (α) and also to the changing illuminance from the headlights. The RA tends to decrease through the approach while the illuminance tends to increase, so the resulting luminance might change in either direction.

Changes in luminance are not necessarily detrimental to sign function. The task of evaluating retroreflective sheetings for signs is therefore more complex than the task of evaluating internally illuminated signs. The method advocated in this British Standard is to calculate the expected sign luminance at four sampled viewing distances for the approach to a sign and to combine the four values into a single figure; the luminance index. The luminance index calculation begins by comparing the luminance provided at each distance with the luminance needed by the driver at that distance. The supplied luminances are calculated from photometry on the sheeting material, in accordance with **6.1** to **6.7**. The demanded luminances are based on human factors research and other assumptions described in this annex, and called "basis luminance".

The luminance index is the harmonic mean of the four ratios of sheeting luminance to basis luminance. Luminance index is a dimensionless quantity defined as follows:

$$LI = \frac{4}{\sum_{1}^{4}\left(\frac{\text{basis luminance}}{\text{sheeting luminance}}\right)} \qquad (F.1)$$

The luminance index can be calculated for each vehicle type at each distance subclass with each entrance angularity subclass. Different types of road signs have different basis luminance, and there are correspondingly two types of luminance index.

a) For direction signs (for all distance subclasses, angularity subclasses, and vehicle types) the basis luminance is:

Basis for Luminance Index A
10 cd·m^{-2} at the longest distance
4 cd·m^{-2} at the next distance
3 cd·m^{-2} at the next distance
3 cd·m^{-2} at the shortest distance

b) For warning and regulatory signs (for all distance subclasses, angularity subclasses, and vehicle types) the basis luminance is:

Basis for Luminance Index B
3 cd·m^{-2} at the longest distance
3 cd·m^{-2} at the next distance
3 cd·m^{-2} at the next distance
3 cd·m^{-2} at the shortest distance

For each combination of vehicle type, distance subclass and entrance angularity subclass, four sheeting luminance values are obtained. When applied to these four luminance values, equation F.1 yields:

a) a Luminance Index A when the first basis luminances are used in the equation; and
b) a Luminance Index B when the second basis luminances are used in the equation.

Thus there is both Luminance Index A and Luminance Index B for each combination of vehicle type, distance subclass and entrance angularity subclass.

The basis for Luminance Index A derives partly from the work of T. Forbes [4 and 5] on the dependence of legibility on luminance. Forbes found that for night-time viewing of signs, legibility increases with the logarithm of luminance. Forbes measured legibility as the ratio of viewing distance to letter size, and he took the luminance as the larger of that of the characters and that of the background. For white-on-blue or blue-on-white signs, Forbes found the relation expressed in equation F.2.

$$D/V = 2.35 + 2.07\ \mathrm{Log}_{10}L \qquad \text{(F.2)}$$

where:

D is distance in metres,
V is letter height in centimetres,
L is luminance in cd·m^{-2}.

Thus the second constant has dimensions square metre/candela.

The corollary of Forbes's work is that, as a sign is approached at night and the required legibility (D/V) decreases, the required luminance also decreases. The luminance required for legibility is an exponential function of distance, D, as in equation F.3, equivalent to equation F.2.

$$L = 0.073 \times 3.04^{D/V} \qquad \text{(F.3)}$$

When the constants in equation F.3 are adjusted to account for UK letter-sizing convention (based on the lower case "x") and the UK assumption that a 15 cd·m^{-2} sign is adequately legible when D/V = 6, equation F.4 is produced.

$$L = 0.073 \times 2.43^{D/V} \qquad \text{(F.4)}$$

Where, for example, a sign with lower case letter size V = 20 cm is expected for distance subclass D2, equation F.4 indicates that the luminance required for legibility is as presented in Table F.1.

Table F.1 — Luminance required for legibility of letter size V=20 cm for distance subclass D2

Distance (m)	**Luminance** (cd·m^{-2})
120	15.0
110	9.6
90	4.0
70	1.6
50	0.7
40	0.4

Between the upper and lower viewing distances, 120 m and 40 m, are the four distances 110 m, 90 m, 70 m, 50 m approximately sampled (see Table D.2). Table F.1 explains the 10 cd·m^{-2} and the 4 cd·m^{-2} for the two longer sampled distances in the basis for Luminance Index A. However, the luminance required for legibility at the closer distances is extremely low according to equation F.4. In order to provide adequate conspicuity and overcome possible glare from oncoming vehicles at all distances, this should be at least 3 $cd \cdot m^{-2}$, and this value supersedes the equation F.4 values at the closer two sampled distances. Thus the basis for Luminance Index A has been developed partly for sign legibility and partly for sign conspicuity. The 3 $cd \cdot m^{-2}$ plateau also provides a safety margin for drivers with weaker vision.

For warning and regulatory signs the reading task is negligible, or is assured by large legend size, or is so slight as to be brief (which can wait until D/V is small). For this reason, luminance is required only for conspicuity, rather than legibility. Luminance of 3 $cd \cdot m^{-2}$ is sufficient for conspicuity in environments that are not brightly lit. Thus, the basis for Luminance Index B is 3 $cd \cdot m^{-2}$ at all distances. **I.4.7** describes how Luminance Index B is applied in brightly lit environments.

The harmonic averaging in equation F.1 reduces the influence on the overall rating where the sheeting material luminance greatly exceeds the basis luminance, while penalising strongly where the sheeting luminance falls far below the basis luminance. Equation F.1 ensures that multiplying the luminance of a sheeting by some constant, k, at all distances multiplies the luminance index by the same constant, k.

In order to judge the applicability of a sheeting material for a particular sign, it is necessary to correct the luminance index for the sign's lateral location with respect to the road, as described in Annex I. As in earlier annexes, discussion is limited here to a typical left hand verge-mounted sign.

For white sheeting on a direction sign:

— Luminance Index A ≈ 0.5 is inadequate performance;
— Luminance Index A ≈ 1 is adequate performance;
— Luminance Index A ≈ 2 is excellent performance.

For white sheeting on a warning or regulatory sign, not in a brightly lit environment:

— Luminance Index B ≈ 0.5 is inadequate performance;
— Luminance Index B ≈ 1 is adequate performance;
— Luminance Index B ≈ 2 is excellent performance.

Annex G (informative)
Guide to selecting entrance angularity subclasses for specifiers

G.1 Retroreflection

The property of retroreflective materials which distinguishes them from other reflective materials is their ability to return light back toward the light source (e.g. the headlamps of a motor vehicle). This property functions even when that light is not head-on, but is incident upon the sign at some angle. That angle is the entrance angle.

Existing prismatic retroreflective sheeting materials reflect a decreasing proportion of the incident light as the entrance angle becomes larger and larger. This efficiency drop-off usually follows a complex curve, and is different for each sheeting material. Specifiers should select the smallest angularity subclass that includes the entrance angles that do occur where the sign is actually read.

G.2 Distance and entrance angle

G.2.1 *Mounting*

The entrance angle increases slowly as the vehicle approaches the sign, but increases more rapidly when the sign is very close. However, distance is not the only relevant factor in angularity class determination. There are four groups into which signs can be classified in order more easily to determine which entrance angle factors need to be considered. These sign groups are given in **G.2.1.1** to **G.2.1.4**.

G.2.1.1 *Signs on straight roads*

Typically, road signs are so placed that they face towards oncoming traffic. Often they are turned a few degrees away from the road so that light from a vehicle's headlamps reflecting off the face of the sign (specular reflection) is reflected away from the driver. Otherwise, it might cause a brief glare to the driver and temporarily make the sign hard to read. Nevertheless, on straight roads, taking all factors into account, signs are commonly mounted sufficiently close to normal that they are, over the relevant range of reading distances, at quite small entrance angles and are in subclass A1 (entrance angles up to 15°).

G.2.1.2 *Entrance angle by lateral displacement*

For distance classes D1 and D2, entrance angles created by lateral displacement are not large enough to exceed subclass A1. For distance classes D3 and D4, entrance angles caused by lateral displacement can exceed subclass A1 at the near end of the distance class, requiring subclass A2 but never subclass A3. This is based on the assumption that one lane and a verge might separate the driving lane from the sign, whether left or right mounted.

Overhead gantry signs are at a fixed vertical displacement of about 6 – 7 m above vehicle headlamps and directly face oncoming traffic on high-speed motorways in distance class D1, and are always within class A1.

G.2.1.3 *Signs mounted at a fixed angle on a straight road and on curves of 800 m radius or more*

A variety of circumstances can result in a sign being mounted at a significant angle to the vehicle direction and being illuminated at that angle throughout the vehicle's approach. These relate to the sign's mounting position, rather than the road configuration, and include the following:

a) space restrictions forcing a sign to be mounted at a significant angle,

b) the mounting of a sign so that it is viewed by two directions of converging traffic (better luminance is provided if each traffic direction had its own sign, properly facing that traffic);

c) the location of a sign at a bend or on a roundabout and positioned for that traffic but which is also intended to be viewed by traffic on a straight approach road.

In these three general cases, the entrance angle is basically fixed at one value, varying only slightly with the approach of a vehicle, and is easily measured. The angle within the appropriate viewing distance range is determined and the angularity subclass covering this (A1, A2, or A3) selected.

G.2.1.4 *Signs on a curved road*

Signs on curved roads and mounted accordingly do not produce significant entrance angles; the entrance angle varies less than 10 degrees as a vehicle traverses the distance range along the curve. A properly-mounted sign, aimed at the mid-point of the distance range, will fall within subclass A1.

Table I.3 gives luminance adjustments according to the illuminance on differently placed signs on a straight road. For a curved road, the effective lateral displacement for headlamp illumination is much greater than for a straight road and the illuminance is less, requiring further adjustment. The luminance of a sign on a curved road is unusually low for the farther half of the distance range owing to the headlights facing away from the sign.

There might be signs that fall outside the above categories and require individual analysis. Computer programs that provide data for such analysis are available.

Annex H (informative)
Calculation of night-time colour contrast factor

H.1 General

Signs are manufactured in prescribed colour combinations. Drivers rely on colour contrast between the different elements of a sign for adequate legibility. When used in the colour combinations set out in Table H.1, the following colour contrast factors are recommended.

Table H.1 — Contrast factors

Colour 1	Colour 2	Min R_A factor	Max R_A factor
White	Red	0.12	0.35
	Blue	0.03	0.15
	Dark green	0.03	0.15
	Brown	0.015	0.10
Yellow	Red	0.15	0.45
	Blue	0.03	0.20
	Light green	0.03	0.25
	Dark green	0.02	0.20
Red	Blue	0.10	0.50

H.2 Worked example of the calculation of night-time colour contrast factor (K)

The night-time contrast factor (K) for two colours is the smaller value of R_A, divided by the larger value:

$$K = \frac{R_{A\ small}}{R_{A\ large}} \tag{H.1}$$

EXAMPLE:

Purpose:

To evaluate the contrast factor of the combination white and blue (representative of a traffic sign with white legend on a blue background).

Measurements:

Coefficient of retroreflection R_A ($cd \cdot lx^{-1} \cdot m^{-2}$) measured at observation angle $\alpha = 0.33°$ and entrance angle $\beta_1 = 0°$, $\beta_2 = 5°$, $\varepsilon = 0°$

White $R_{A\ large} = 385\ cd \cdot lx^{-1} \cdot m^{-2}$
Blue $R_{A\ small} = 23\ cd \cdot lx^{-1} \cdot m^{-2}$

Calculation of contrast factor:

$$K = \frac{23}{385} = 0.06$$

Contrast factors recommended in Table H.1:

min 0.03, max 0.15

Conclusion:

Contrast is satisfactory.

Annex I (informative) Guidance for specifiers on the selection of sheeting

I.1 Introduction

This annex shows specifiers how to use the luminance index either to specify the luminance performance required for a given sign location or to determine from a manufacturer's test certificate whether sheeting material meets their needs. In the latter case, adjustments have to be made to the certified luminance index to take account of sign location (see **I.4.6**). This converts the luminance index to the performance index. Worked examples of the sheeting selection procedure are provided in **I.6**. A sample table comparing sheeting performance with the requirements for various combinations of road type, sign location and vehicle type (Table I.5) demonstrates the application of the calculated output from the data entered in the sample form given in Figure 7A (**6.8**).

The luminance index calculations which result in the array of data in Figure 7A are presented in the form of a test report. An example of a test report is shown in Table E.20A and Table E.20B. The report indicates a numerical value for each listed combination of distance subclass, entrance angularity subclass and vehicle type.

I.2 Information for the selection of sheeting

The following information is essential for the selection of sheeting:

a) the type of sign required; whether it contains a legend, such as a directional sign, or mainly symbols, such as a warning or regulatory sign;
b) the intended lateral location and mounting height of the sign: near side, off side or overhead;
c) the largest entrance angle encountered over the relevant viewing distance (see Figure I.1);
d) the proportion of large vehicles in night-time traffic on the stretch of road on which the sign is to be located;
e) whether there is street lighting on the stretch of road on which the sign is to be located; and
f) the 85th percentile speed of traffic on the approach to the proposed location of the sign.

I.3 Background

The starting point for this annex is Figure 7A and Figure 7B. Luminance Index A is intended for signs chiefly comprising a legend (e.g. directional and informatory signs). Luminance Index B is intended for regulatory and warning signs, which are primarily symbolic or have large characters relative to the viewing distance, e.g. speed limit signs. In the interests of simplicity, supplementary plates may employ the same material as the main sign with which they are used.

The performance index needed is normally at least 1.0. This generally ensures adequate legibility for directional signs, and adequate conspicuity for warning and regulatory signs. The latter tend to be largely symbolic, so that outright legibility is less likely to be an issue. On unlit roads, this minimum applies to the performance index derived for both Luminance Indices A and B. Where street lighting is present, the performance index derived from Luminance Index B (symbolic signs) needs to be a minimum of 3.0, in order to ensure adequate conspicuity for these generally smaller and often safety-critical signs. Where such a sign is to be directly lit by a luminaire that is provided for the purpose, and which meets the luminance requirements of the relevant British or European Standards, it is not necessary to specify a luminance index requirement.

I.4 Selection of the rating category

I.4.1 *General*

To determine which of the rating categories applies to a given sign application, it is necessary to determine:

a) the viewing distance range (D1, D2, D3 or D4) (see Table I.1);

b) the entrance angularity (A1, A2, A3) (see Figure I.1 and Table I.2);

c) the sign category (A for legend or B for symbolic);

d) the relevant vehicle type (V1 or V2);

e) the sign location (P1, P2, P3 or P4) — (see Figure I.2); and

f) the performance index requirement (1.0 for unlit, 1.0 or 3.0 for lit roads — see Table I.4).

Each step is explained in more detail in **I.4.2** to **I.4.7**.

I.4.2 *Determining the distance range*

In general, the prevailing traffic speed on a given stretch of road determines the selection of the letter size (x-height). The x-height determines the maximum legibility or recognition distance. The appropriate x-height should be determined from Appendix A in Local Transport Note (LTN) 1/94 [6]. The viewing distance subclasses to be used for typical x-height at typical driving speed is given in Table I.1. If, for example, the typical driving speed on the relevant stretch of road is 70 mph and the sign x-height is 300 mm, the distance subclass D1 is used. Regulatory and warning signs will use the same distance sub-class as appropriate for directional signs on that road.

Table I.1 — Legibility or recognition range of letter size at selected viewing distance subclasses

Typical driving speed mph	Typical x-height mm	Distance subclass	Legibility or recognition range m
70	300	D1 (long)	200–50
60–70	250	D1 (long)	200–50
50–60	200	D2 (medium)	120–40
40–50	150	D3 (short)	90–30
30–40	125	D3 (short)	90–30
20–30	100	D3 (short)	90–30
20–30	75	D4 (close)	50–20

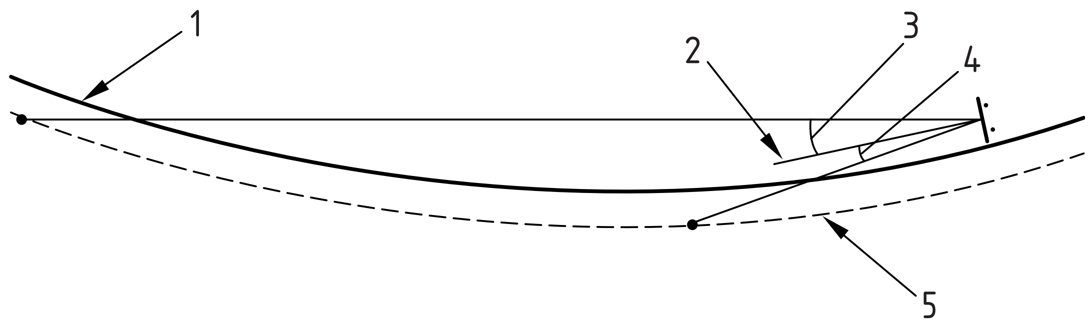
I.4.3 ***Determining the entrance angularity classification***

The entrance angularity classification categorizes the maximum entrance angle of a sign relative to an approaching vehicle. Both the dynamic change in the entrance angle experienced by the driver as the sign is approached and the static installation angle of the sign, which is a component of the entrance angle, have to be considered. Figure I.1 shows how the entrance angle varies with distance when the road beside which it is located bends.

The entrance angularity subclass to be selected is determined by the largest entrance angle encountered over the applicable distance subclass range. The largest entrance angle does not necessarily occur when a vehicle is closest to the sign (see Figure I.1). Typically, angularity requirements can be higher for signs to be located on lower speed roads with sharp bends or roundabouts, or for signs to be viewed from two directions of traffic flow.

NOTE Additional guidance is given in Annex G.

The smallest angularity subclass (A1, A2 or A3 — see Table 7) in which the maximum entrance angle falls is selected. For example, the entrance angularity subclass A2 is used for a sign with a maximum entrance angle of 20º.



Key
1 = Edge of carriageway
2 = Normal to the sign
3 = Entrance angle (1)
4 = Entrance angle (2)
5 = Vehicle path

Figure I.1 — Variation in entrance angle with distance

Table I.2 — Entrance angularity subclasses

Entrance angularity subclass	Entrance angle β
A1 narrow	Up to 15°
A2 medium	Up to 30°
A3 wide	Up to 40°

I.4.4 ***Determining the sign category***

Signs generally fall into two categories; those comprising a legend and those that are largely symbolic. They have different luminance needs, identified as Luminance Index A and Luminance Index B respectively (see I.3 and Annex F). Legend signs require sufficient luminance to be read at the letter detail level by the vehicle driver. These are generally classified using Luminance Index A. Examples are destination names on directional signs. Symbolic signs are signs that are recognised by their shape or bold symbols, or which use large numerals. These are generally classified using Luminance Index B. Examples are "Stop" and "Give Way" signs and speed limit signs. For these signs, conspicuity rather than legibility is the dominant requirement.

I.4.5 ***Determing the vehicle type***

There are two vehicle subclasses, passenger car (V1) and large vehicles (V2). The selection of vehicle subclass depends upon the mix of vehicle types using the road at night. This mix of vehicles can vary substantially. On some roads, the proportion of lorries at night can be over 60 %, but on others, the proportion might be less than 10 %. In determining the appropriate vehicle class, the significance of the lorry usage is considered. Since the performance of virtually all retroreflective materials is usually lower for drivers of large vehicles, acceptance based on the V2 class generally ensures that a sign also works well for the drivers of passenger cars (see Table D.3 for dimensions of the two types of vehicles).

I.4.6 ***Determining the correction factor for sign location***

Sign location significantly influences the luminance available to a vehicle driver. Signs located on an overhead gantry, for example, receive less light than those located on the left shoulder (left verge mounted). Since the luminance indices calculated in this standard are for left verge mounted signs, appropriate corrections are needed to determine performance of signs proposed for other locations. The illuminance at the midpoint of each viewing distance class (from Annex C) has therefore been used to determine the relative correction factors for each of the four sign locations illustrated in Table I.2. These corrections are different for passenger cars and large vehicles, reflecting their different headlamp positions. The correction factors for sign locations P1 to P4 are given in Table 12, and repeated for convenience in Table I.3. Once the sign location is determined, the correction from Table I.3 can be applied. The luminance index then becomes the performance index.

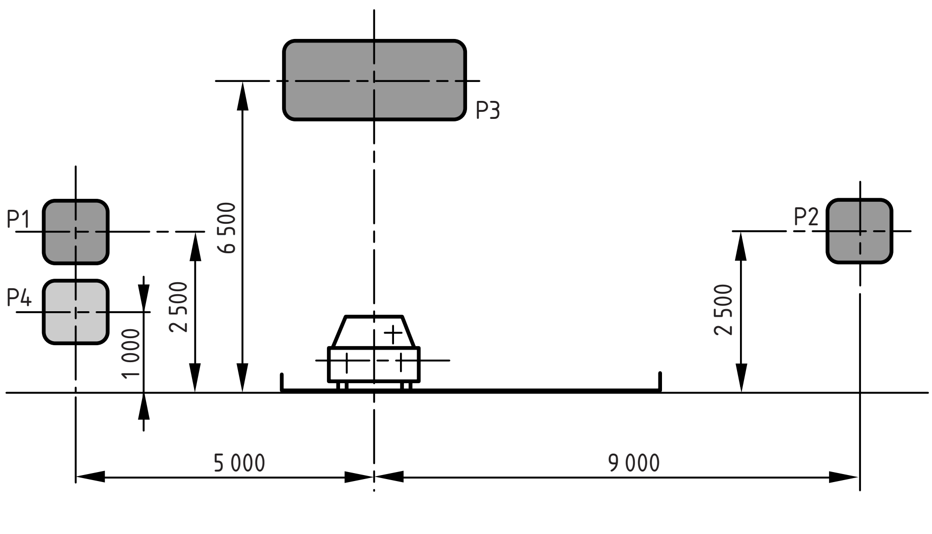


Figure I.2 — Sign locations

Table I.3 — Sign location correction factors

Location category		Distance class							
		D1		D2		D3		D4	
		V1 Car	V2 Large vehicle	V1 Car	V2 Large vehicle	V1 Car	V2 Large vehicle	V1 Car	V2 Large vehicle
P1	Left verge	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P2	Right verge	0.73	0.72	0.73	0.71	0.64	0.64	0.50	0.49
P3	Overhead	0.46	0.45	0.51	0.47	0.39	0.39	0.36	0.39
P4	Low left	2.75	3.19	7.98	9.04	9.92	13.79	9.38	11.62

I.4.7 *Determining the required performance index for the ambient illumination*

Surrounding illumination can have an impact on the conspicuity of signs. Many verge-mounted signs, mainly warning and regulatory signs, are illuminated externally to compensate for the lack of conspicuity on lit roads. The required performance index for signs relying upon retroreflection is dependent upon the surrounding illumination level. Two levels are used for specifying sign performance. The nominal index 1.0 based on corrected performance Luminance Index A or Luminance Index B is used in unlit environments. For symbolic and warning signs on lit roads requiring the corrected performance Luminance Index B, the requirement is recommended to be set at 3.0 (see Table I.4), unless the sign is directly lit by a specially-provided luminaire.

Table I.4 — Performance index needs for drivers

Sign type	Performance index needs	
	Unlit road	Lit road
Legend (informatory signs)	1.0	1.0
Symbolic (warning and regulatory signs)	1.0	3.0

I.5 Examples of performance index for some frequently-used UK signs

Table I.5 lists common UK sign types. By applying the appropriate location factors to the values used to populate the sample forms in Figure 7A and Figure 7B (see Table E.20A and Table E.20B), and comparing the results to the performance index requirements indicated in **I.4.7**, the performance of a given microprismatic sheeting can be determined. When the results are less than the nominal requirement, the material should not be used in that application unless the sign is directly lit.

Table I.5 does not cover every application that might be encountered. In cases where the application is not listed, the criteria in **I.4.1** are used to establish the required rating category. For example, a directional sign on a high-speed principal road which has angularity greater than 15° might require a rating category of D2, A2, V1, P1, Luminance Index A.

Table I.5 — Performance index results, using the sheeting assessed in Annex E

Road type	Sign	Distance and Angularity	Luminance category	Vehicle type	Sign location	Rating category code	Correction factor (from Table I.3)	Performance index (from Table E.20)	Performance index requirement		Pass (P) or Fail (F)	
									Unlit	Lit	Unlit	Lit
Motorway	Directional (left verge)	D1 A1	A	V1	P1	D1 A1 V1 P1 A	1.00	2.48	1	1	P	P
Motorway	Directional (gantry)	D1 A1	A	V1	P3	D1 A1 V1 P3 A	0.46	1.14	1	1	P	P
Motorway	Directional (left verge)	D1 A1	A		P1	D1 A1 V2 P1 A	1.00	1.15	1	1	P	P
Motorway	Directional (gantry verge)	D1 A1	A		P3	D1 A1 V2 P3 A	0.45	0.52	1	1	F	F
Principal – 60mph	Directional (left verge)	D2 A1	A	V1	P1	D2 A1 V1 P1 A	1.00	4.31	1	1	P	P
Principal – 60mph	Directional (gantry)	D2 A1	A	V1	P3	D2 A1 V1 P3 A	0.51	2.20	1	1	P	P
Principal – 60mph	Symbolic (left verge)	D2 A2	B	V1	P1	D2 A2 V1 P1 B	1.00	3.85	1	3	P	P
Principal – 60mph	Symbolic (right verge)	D2 A2	B	V1	P2	D2 A2 V1 P2B	0.73	2.81	1	3	P	F
Principal – 40mph	Directional (left verge)	D3 A2	A	V1	P1	D3 A2 V1 P1 A	1.00	2.24	1	1	P	P
Principal – 40mph	Directional (right verge)	D3 A2	A	V1	P2	D3 A2 V1 P2 A	0.64	1.43	1	1	P	P
Principal – 40mph	Symbolic (left verge)	D3 A2	B	V1	P1	D3 A2 V1 P1 B	1.00	3.39	1	3	P	P
Principal – 40mph	Symbolic (right verge)	D3 A2	B	V1	P2	D3 A2 V1 P2 B	0.64	2.17	1	3	P	F
Low speed	Symbolic (left verge)	D3 A3	B	V1	P1	D3 A3 V1 P1 B	1.00	2.17	1	3	P	F
Low speed	Symbolic (right verge)	D3 A3	B	V1	P2	D3 A3 V1 P2 B	0.64	1.39	1	3	P	F

NOTE The performance column shows the location-corrected results from Table E.20A and Table E.20B for certain typical signs. These are calculated by multiplying the relevant Luminance Index A or Luminance Index B (from Table E.20A or Table E.20B) by the sign location correction factor from Table I.3, e.g. for a motorway left verge mounted sign (D1, A1), vehicle type V1, luminance category A, the performance index for the hypothetical sheeting in Table E.20A is 2.48, but for a gantry-mounted sign, this has to be multiplied by a factor of 0.46 (see Table I.3), resulting in a performance index of 1.14.

I.6 Examples of sheeting specification procedure

Example 1

In this example, the sheeting specification is determined for a directional sign mounted on the near side of a straight road with a system of street lighting. The centre of the sign is offset 6 m from the centre of the driving lane. The sign is installed at 95° to the centre line and the centre of the sign is 2.5 m above the carriageway. The night-time percentage of HGVs is 10 % and the 85th percentile speed of traffic on this road is 45 mph.

Following the procedures given in **I.4.1**, the following are determined.

a) The distance subclass — the letter x-height appropriate for this sign is 150 mm (see LTN 1/94, Appendix A [6]); the viewing distance subclass (from Table I.1) is D3 (90 – 30 m).

b) The entrance angularity subclass — for this sign, the largest entrance angle occurs at 30 m distance.

NOTE 1 With a 6 m offset, the entrance angle for a sign perpendicular to the road is 11°. With a 5° installation angle to prevent specular reflection, the total entrance angle is 16°. This gives an entrance angularity subclass A2 (see Table I.2).

c) The sign category — this is a directional sign, for which Luminance Index A applies (see **I.4.4**).

d) The vehicle type — as the night-time percentage of HGVs is relatively low, the decision might be taken to consider only passenger cars; the relevant vehicle class would then be V1 (see **I.4.5**).

NOTE 2 Where the percentage of HGVs is high, there might be a strong case for using the vehicle class V2. The likely proportion of overseas HGV drivers, e.g. on a road serving a port, would also be a relevant consideration. However, it is often not possible to identify a sheeting that provides the required performance level for the V2 case. The sign specifier then has to decide whether to accept a sheeting that provides adequate performance only for passenger cars, or to light the sign.

e) The sign location — as the sign is to be mounted on the near side at a height of 2.5m, the sign location is P1 (see Table I.3).

f) The performance index requirement — a directional sign on a lit road requires a minimum performance index of 1.0 (see Table I.4).

If a manufacturer's sheeting specification is available (see hypothetical examples in Table E.20A and Table E.20B), the luminance index values can be entered into a table in the form shown in Table I.5, for any range of scenarios of interest. From Table E.20A, the corresponding luminance index for the present case is D3, A2, V1, Luminance Index A, i.e. 2.24. Multiplying this by the P1 location correction factor of 1.00 yields a performance index for this particular sheeting of 2.24 × 1.00 = 2.24. As the performance index requirement for this sign is 1.0, this sheeting would be suitable (see row 9 of Table I.5).

If a manufacturer's test results and specifications are not available, the requirement is a minimum performance index of 1.0 for a situation characterised as D3, A2, V1, P1, Luminance Index A.

If the sign had been a regulatory sign, performance index B in Table E.20B would have been substituted for index A, i.e. the value for D3, A2, V1 would have been 3.39. This would then have been multiplied by the same P1 location correction factor of 1.00, resulting in a performance index of 3.39 × 1.00 = 3.39. This particular sheeting would therefore have been suitable both on an unlit road (requirement 1.0) and on a lit road (requirement 3.0) (see row 11 of Table I.5).

Example 2

The sign is a warning sign mounted on the off side of a straight road having a system of street lighting. The centre of the sign is 6.5 m from the centre of the driving lane and 2.5 m above the carriageway. The night-time percentage of HGVs is 30 % and the 85th percentile speed is 55 mph.

The x-height for a directional sign is 200 mm (LTN 1/94 [6]), so the distance subclass (from Table I.1) is D2 (120 – 40 m).

The largest entrance angle occurs at 40 m distance. With an offset of 6.5 m, the entrance angle for a sign perpendicular to the road is 9°. With a 5° installation angle to prevent specular reflection, the total entrance angle is 14°, resulting in an entrance angularity subclass of A1 (see Table I.2).

This is a warning sign, for which Luminance Index B applies (see **I.4.4**).

As the percentage of HGV traffic is high, the vehicle type selected is V2.

The sign location factor is P2, as the sign is mounted on the off side at a height of 2.5 m (see Table I.3).

A warning sign on a lit road requires a minimum performance index of 3.0 (see Table I.4).

From Table E.20B the corresponding luminance index is found for D2, A1, V2, luminance index B, i.e. 1.14. Multiplying this by the location correction factor of 0.71 (Table I.3) yields a performance index of 1.14 × 0.71 = 0.81. As the performance index required for this sign is 3.0, this particular sheeting does not provide the luminance needed. If no alternative material supplying the required value is available, the sign needs to be directly lit.

Note that if the night-time HGV traffic is assessed as low, so that a passenger car (V1) is the appropriate vehicle type, the luminance index (from Table E.20B) is 7.20 and the location correction factor (Table I.3) 0.73. The performance index then becomes 7.20 × 0.73 = 5.26, easily meeting the required value of 3.0.

If no manufacturer's data sheet is available, a minimum requirement of 3.0 would be specified for a situation characterised as D2, A1, V2 (or V1), P2, Luminance Index B.

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BS 6001-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

BS 6001-2:1993, *Sampling procedures for inspection by attributes — Part 2: Procedures for assessment of declared quality levels*

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BS 6002-4.1:1994, *Sampling procedures for inspection by variables — Part 4.1: Specification for sequential sampling plans for percent nonconforming (known standard deviation)*

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2) BS 6000 is to be published as a three-part series in 2005.

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