CEN/TC 226
Date: [YYYY-MM]
WI 00226xxx
prEN 12899-6
CEN/TC 226
Secretariat: AFNOR

Fixed vertical road traffic signs — Part 6: Retroreflective sign face materials

ICS:
Descriptors:

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT prEN 12899-6

[Date]

[ICS Reference]

English Version

Fixed, vertical road traffic signs - Part 6: Performance of retroreflective sign face materials

Signaux fixes de signalisation routière verticale - Partie 6 : [French title]

Ortsfeste, vertikale Straßenverkehrszeichen - Teil 6: [German title]

This European Standard was approved by CEN on [date].

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. DRAFT prEN 12899-6:[Year]: E

Contents

Foreword

This document (DRAFT prEN 12899-6:[Year]) has been prepared by Technical Committee CEN/TC 226 "Road equipment", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by [date], and conflicting national standards shall be withdrawn at the latest by [date].

No existing European Standard is superseded.

This European Standard consists of the following Parts under the general title:

Fixed, vertical road traffic signs —

Part 1: *Fixed signs*

Part 2: *Transilluminated traffic bollards (TTB)*

Part 3: *Delineator posts and retroreflectors*

Part 4: *Factory production control*

Part 5: *Initial type testing*

Part 6: (This part) *Performance of retroreflective sign face materials*

It is based on performance requirements and test methods published in CEN, CENELEC, CIE (International Commission on Illumination) and ISO documents together with standards of the CEN member organizations.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

The visual performance of retroreflective sign face materials is dependent on their luminance and chromaticity. Retroreflection is the relevant characteristic for the legibility and visibility of road signs during night time driving, while luminance factor and chromaticity are relevant characteristics for the legibility of signs during the daytime (and for illuminated signs at night).

A legend or a symbol on a sign face is presented in one colour against the background of another colour. Bright colours serve generally as signal colours, while dark colours generally serve as contrast colours. A few colours may sometimes serve as signal colours and at other times as contrast colours. The signal colour is considered to be the more important in terms of retroreflective performance.

The situations in which road traffic signs are used are grouped into a number of application classes, and individual signs can be specified using the range of retroreflection performance classes provided. The system of classes is complex - and has to be complex - in order to make good use of retroreflection. A single material cannot supply optimum or even adequate sign legibility in all applications, but some materials can do so in some applications and other materials in other applications.

Test methods for retroreflection are provided in annex A and for luminance factor and chromaticity in annex B. Both annexes are of a complex technical nature, as they deal with retroreflective sign face materials of both known technologies - glass beaded and microprismatic - and because the fluorescence of fluorescent sign face materials has been taken into account. These normative annexes are primarily intended to be studied by experts working at test laboratories.

It is a particular feature of retroreflection that it has limitations. Consequently, application and retroreflection performance classes cannot in practice be selected independently of each other. Some guidelines for the selection of application and retroreflection performance classes are offered in the informative annex. These are intended as the basis for forming national policies for retroreflective road traffic signs, in which various interests are weighed against each other in a suitable manner.

1 Scope

This Part 6 of EN 12899 describes the performance requirements for retroreflective sign face materials.

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.

IEC 50-845 International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting

NOTE: CIE Publication 17.4 International Electrotechnical Vocabulary is identical to IEC 50-845:1987.
ISO/CIE 10526 CIE standard illuminants for colorimetry

CIE 15:2004 Colorimetry

CIE 54.2 Retroreflection: definition and measurement

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

EN ISO 4892-2 Plastics - Methods of exposure to laboratory light sources - Part 1: General guidance

EN ISO 4892-2 Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps

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

3 Terms, definitions, symbols and abbreviations

For the purposes of this European Standard, the terms and definitions given in IEC 50-845 and CIE 54.2 and the following apply.

3.1
Signal colour
The brightest colour of the sign face of a retroreflective sign.

NOTE: The signal colour is white for most signs, but may be yellow, orange, fluorescent yellow, fluorescent yellow/green or fluorescent orange.

3.2
Contrast colour
Any colour of the sign face of a retroreflective sign (including non-retroreflective black) that is not the signal colour.

3.3
Coefficient of retroreflection (of a plane retroreflecting surface), symbol R_A

Ratio of the luminous intensity of a plane retroreflecting surface in the direction of observation to the illuminance at the retroreflecting surface measured on a plane perpendicular to the direction of the incident light in proportion to the area of the retroreflecting surface.

NOTE: The value of the coefficient of retroreflection depends in principle on four angles, this being the number of angles needed to describe the directions of observation and incident light relative to the retroreflecting surface. Refer to CIE 54.2 for the definition of such angles and their combination into angular systems. R_A is expressed in $cd.lx^{-1}m^{-2}$ units.

3.4

$R_{A,C}(\alpha,\beta)$ value

A calculated value of the coefficient of retroreflection R_A for a combination of the observation angle α and the entrance angle β

Definitions of the observation angle α and entrance angle β are provided in CIE 54.2.

NOTE1: A value of the observation angle α relates, among other things, to the distance to a road sign, and a value of the entrance angle β relates to the obliqueness at which the sign is illuminated.

NOTE 2: The $R_{A,C}(\alpha,\beta)$ value is calculated from various R_A measurements in which two additional angles have been varied.

One additional angle relates to the location of a headlamp on a vehicle relative to the driver, for instance directly below the driver, below to the right and below to the left. The other additional angle relates to the location of a sign relative to the vehicle, for instance to the right, above or to the left of the vehicle.

The calculation of the $R_{A,C}(\alpha,\beta)$ value is carried out in two steps:

- I: R_A values are averaged for three different headlamp locations.
- II: the smallest of these values for some relevant locations of a road sign relative to the vehicle is selected to be the $R_{A,C}(\alpha,\beta)$ value.

This calculation ensures that the $R_{A,C}(\alpha,\beta)$ value is a reasonable representation of the coefficient of retroreflection R_A taking account of variation in vehicle type and sign location.

3.5

Application class

A class defining the geometrical circumstances in which a road sign is to be read, comprising a set of combinations of observation angles α and entrance angles β.

NOTE: The application class which is the most suitable for drivers of small vehicles may be less suitable for drivers of large vehicles.

3.6

R_A index

An index providing a single measure of the general level of retroreflective performance of a sign face material for the geometrical circumstances of an application class.

NOTE: The R_A index value is obtained in three steps. These are numbered III, IV and V in continuation of two steps I and II used to derive $R_{A,C}(\alpha,\beta)$ values above:

- III: The proportions between the $R_{A,C}(\alpha,\beta)$ values of a sign face material and a set of $R_{A,R}(\alpha,\beta)$ reference values are calculated.
- IV: For each of the entrance angle values included within the application class, the harmonic average of the above-mentioned proportions are calculated for those cases of the observation angles that are included within the application class.
- V: The smallest of the harmonic averages is selected to be the R_A index.

The $R_{A,R}(\alpha,\beta)$ reference values correspond to a constant sign luminance of 1 cd/m^2.

3.7
Retroflection performance class
A classification based on the R_A index value of a signal colour for a given application class.

3.8
Mounting axis
A direction relative to a retroreflective sign face material indicating the orientation with which the sheeting is to be mounted on a road sign so that the mounting axis is pointed upwards.

NOTE 1: A mounting axis can be indicated by a datum mark on the material or can be the direction of the roll of the material or can be indicated in other ways and shall be declared by the manufacturer of the sheeting.

NOTE 2: If the manufacturer declares more than one mounting axis, one mounting axis is distinguished as the primary mounting axis while the others are secondary mounting axes.

3.9
Family of retroreflective sign face materials
A family of retroreflective sign face materials consists of sheetings in various colours (including non-retroreflective black) with identical optical design and similar manufacturing processes and raw materials (except dyes or pigment) and includes materials with process colour or coloured overlay film and with clear overlay film.

3.10
Fluorescence
Fluorescence is primarily a daylight appearance attribute based on absorption of light at shorter wavelengths and emission at longer wavelengths.

4 Retroreflection of sign face materials

4.1 General

The performance of retroreflective sign face materials is dependent on the properties of the sheeting, which are affected by the geometry of viewing, luminance factor and chromaticity. Because the geometry of viewing is important it is essential that the material is applied to the substrate correctly. To this end, datum marks and mounting axes are required to be included in the construction of sheeting.

Information about datum marks and mounting axes are provided in annex A. Chromaticity and luminance is covered in Clause 5.

The Standard defines a number of application classes which are described in 4.2 and specified in tables 2 and 3.

Each application class is defined by five observation angles covering the reading distance range. With each observation angle there are entrance angles to represent the angle of illumination of the sign that will occur.

A performance value is determined for each application class for each sign face material by means of an average value which represents the performance of that sign face material.

The process starts with selecting an application class to match the site of the proposed installation.

The next step is to calculate a representative R_A value denoted the $R_{A,C(\alpha,\beta)}$ value for each of these application classes. This is described in Annex A.

From this, an R_A index is calculated for a particular application class, which in turn leads to the performance class (P1 to P8) for that application class.

The manufacturer of a sheeting material may provide the retroreflection performance classes for one, more or all of the application classes. For those application classes, where the retroreflection performance classes are not provided, the testing need not be carried out.

NOTE: A sheeting material may be designed to perform well for some application classes and less well for other application classes, for which it may not comply with the lowest retroreflection performance class (P1) or it may not be competitive to other sheeting materials.

Purchasers should use this system of application and retroreflection performance classes to specify their requirements.

Some colours are used for both signal and contrast colours, and non-retroflective black is also used as a contrast colour. Separate test methods are specified for signal and contrast colours (see 4.3 and 4.5 respectively). Requirements for non-retroreflective black are specified in EN 12899-1.

The signal colour is the more important in terms of retroreflective performance.
Guidelines for the selection of application and performance classes are given in annex C.

The manufacturer of a sheeting material shall declare the mounting axis. The manufacturer can declare more than one mounting axis, refer to 4.4. If so, one mounting axis is distinguished as the primary mounting axis while the others are secondary mounting axes. Secondary mounting axes are defined by clockwise rotations relative to the primary mounting axis.

A material that has been assigned multiple mounting axes can be mounted on signs with rotations corresponding to the different mounting axes. However, within a sign, the mounting has normally to correspond to a single mounting axis with the exceptions provided in the next two paragraphs.

A specific way to declare more than one mounting axis is to declare mounting axis reversal symmetry or mounting axis rotation symmetry, meaning respectively that the material can be applied with a 180° rotation, or with any rotation.

Symmetries of this nature allow not only that a material can be mounted on signs with rotations corresponding to the different datum axes, but normally also mounting with more than one mounting axis within a sign.

4.2 Application classes for signal colours

The classifications are based on comparison of $R_{A,C}(\alpha,\beta)$ values of the signal colour with the $R_{A,R}(\alpha,\beta)$ reference values provided in table 1 for particular cases of α and β.

Table 1: $R_{A,R}(\alpha,\beta)$ reference values for white parts of road signs

Observation angle α	Entrance angle β			
	5°	15°	30°	40°
0,20°	66,4	64,4	57,7	51,0
0,33°	32,9	31,9	28,6	25,3
0,50°	18,4	17,8	16,0	14,2
0,70°	11,5	11,1	9,99	8,84
1,00°	6,97	6,76	6,06	5,36
1,50°	3,95	3,83	3,44	3,04
2,00°	2,64	2,56	2,30	2,03

NOTE 1: The observation angle α relates to the distance between a sign and a vehicle (small α corresponds to a large distance), while the entrance angle β relates to the obliqueness with which the headlight of the vehicle illuminates the sign.

NOTE 2: The $R_{A,R}(\alpha,\beta)$ reference values correspond to a constant sign luminance of 1 cd/m^2. These values are provided in table 1 and come from the function $R_A = 6{,}99\times\alpha^{-1{,}4}\times\cos\beta$ (see annex C for further details).

The comparison between $R_{A,C}(\alpha,\beta)$ values of the signal colour and $R_{A,R}(\alpha,\beta)$ reference values is limited to one or more selections of cases of α and β as indicated in table 3. These selections correspond to the application classes given in table 2:

Table 2: Road descriptions for application classes

Class	Reading distance description	Values of entrance angle
A11	Long	5º
A12		15º
A13		30º
A21	Medium	5º
A22		15º
A23		30º
A24		40º
A31	Short	5º
A32		15º
A33		30º
A34		40º

Long, medium and short distances relate to ranges of distances that are relevant for signs on different types of roads depending on driving speeds and other matters. Narrow, medium, wide and extra wide entrance angularity refers to the need to ensure performance in situations with oblique light incident on the signs.

Two or more classes of entrance angularity can be requested simultaneously.

EXAMPLE: In recognition that the majority of signs are positioned at small entrance angles, the 5° entrance angularity class can be applied with a high retroreflection performance class. Simultaneously a lower retroreflection performance class can be applied for the 15° and 30° entrance angularity class, as there are likely to be some signs viewed at larger entrance angles. This would emphasise the performance requirement for the majority of signs that are positioned at small entrance angles and still require a level of performance for those signs viewed at wider entrance angles.

The classes A11, A21 and A31 shall only be requested in combination with other application classes with wider entrance angularity, as the narrow entrance angularity is not sufficient in itself. Refer to C.7 for further information.

Table 3: Selections of cases for application classes A11, A12, A13, A21, A22, A23, A24, A31, A32, A33 and A34

<table>
<tr><td>α</td><td>0.20°</td><td>0.33°</td><td>0.50°</td><td>0.70°</td><td>1.00°</td><td>1.50°</td><td>2.00°</td></tr>
<tr><td>β</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5°</td><td colspan="5">Class A11</td><td></td><td></td></tr>
<tr><td>5°</td><td colspan="5" rowspan="2">Class A12</td><td></td><td></td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>5°</td><td colspan="5" rowspan="3">Class A13</td><td></td><td></td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>30°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td colspan="5">Class A21</td><td></td></tr>
<tr><td>5°</td><td></td><td colspan="5" rowspan="2">Class A22</td><td></td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td colspan="5" rowspan="3">Class A23</td><td></td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>30°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td colspan="5" rowspan="4">Class A24</td><td></td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>30°</td><td></td><td></td></tr>
<tr><td>40°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td></td><td colspan="5">Class A31</td></tr>
<tr><td>5°</td><td></td><td></td><td colspan="5" rowspan="2">Class A32</td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td></td><td colspan="5" rowspan="3">Class A33</td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>30°</td><td></td><td></td></tr>
<tr><td>5°</td><td></td><td></td><td colspan="5" rowspan="4">Class A34</td></tr>
<tr><td>15°</td><td></td><td></td></tr>
<tr><td>30°</td><td></td><td></td></tr>
<tr><td>40°</td><td></td><td></td></tr>
</table>

4.3 Retroreflection performance classes for signal colours

For a particular signal colour and application class, an R_A index is derived in three steps. These are numbered III, IV and V in continuation of steps I and II used to derive $R_{A,C}(\alpha,\beta)$ values, refer to A.2:

- III: the ratios are calculated between $R_{A,C}(\alpha,\beta)$ values of the signal colour and $R_{A,R}(\alpha,\beta)$ reference values for each of the cases in the selection corresponding to the class
- IV: for each column of β cases within the selection, the harmonic mean of the ratios calculated in step III is calculated
- V: the R_A index value is selected as the smallest of the harmonic means calculated in step IV.

The harmonic means to be determined in step IV include five ratios R_1, R_2, R_3, R_4 and R_5. The harmonic mean is determined as

$$\bar{x}_{\mathbf{harm}} = \frac{n}{\sum_{i=1}^{n} \frac{1}{x_i}}.$$

NOTE: The R_A index is a single measure of the general level of retroreflection of a sign face material as compared to the $R_{A,R}(\alpha,\beta)$ reference values. An R_A index applies for a particular application class; the value will in general depend on the application class.

EXAMPLE 1 (applies to application class A23): The R_A index is determined in three steps. In step III the ratios between the $R_{A,R}(\alpha,\beta)$ reference values and the $R_{A,C}(\alpha,\beta)$ values of the signal colour are calculated, in step IV the harmonic means of the ratios are calculated for each relevant case of the entrance angle β and in step V the smallest of these harmonic means is selected.

	$R_{A,R}(\alpha,\beta)$ reference values			$R_{A,C}(\alpha,\beta)$ values of the signal colour		
Observation angle α	Entrance angle β			Entrance angle β		
	5°	15°	30°	5°	15°	30°
0,20°	-	-	-	-	-	-
0,33°	32,9	31,9	28,6	432	370	183
0,50°	18,4	17,8	16,0	340	306	151
0,70°	11,5	11,1	9,99	230	198	97,4
1,00°	6,97	6,76	6,06	103	89,1	44,0
1,50°	3,95	3,83	3,44	28,2	25,2	11,3
2,00°	-	-	-	-	-	-

		Entrance angle β		
		5°	15°	30°
Step III	ratios: $R_{A,C}(\alpha,\beta)/R_{A,R}(\alpha,\beta)$	-	-	-
		13,1	11,6	6,40
		18,5	17,2	9,44
		20,0	17,8	9,75
		14,8	13,2	7,26
		7,14	6,58	3,28
		-	-	-
Step IV	harmonic means:	12,9	11,7	6,19
Step V	minimum:	6,19		

For a particular application class, the R_A index is used to decide the retroreflection performance class in accordance with the minimum requirements of table 4.

An R_A index is valid only for a particular means of obtaining the signal colour (e.g. inherent colour, use of an overlay film of a particular type or process colour with a particular dye according to a particular procedure) and shall be determined separately for other means of obtaining the signal colour.

Table 4: Minimum requirements for retroreflection performance classes

Retroreflection performance class	Signal colour		
	White	Yellow Fluorescent Yellow and Yellow-green	Orange Fluorescent Orange
P1	R_A index ≥ 1,4	R_A index ≥ 1,0	R_A index ≥ 0,7
P2	R_A index ≥ 2,0	R_A index ≥ 1,4	R_A index ≥ 1,0
P3	R_A index ≥ 2,8	R_A index ≥ 2,0	R_A index ≥ 1,4
P4	R_A index ≥ 4,0	R_A index ≥ 2,8	R_A index ≥ 2,0
P5	R_A index ≥ 5,6	R_A index ≥ 4,0	R_A index ≥ 2,8
P6	R_A index ≥ 8,0	R_A index ≥ 5,6	R_A index ≥ 4,0
P7	R_A index ≥ 11,3	R_A index ≥ 8,0	R_A index ≥ 5,6
P8	R_A index ≥ 16,0	R_A index ≥ 11,3	R_A index ≥ 8,0

EXAMPLE 2 (for application class A23): Further to EXAMPLE 1, the highest retroreflection performance class that can be met by a product with an R_A index of 6,19 for the signal colour white is P5 (i.e. R_A index ≥5,6).

4.4 Derivation of the R_A index for secondary mounting axes

For the signal colour white, the R_A index shall be derived independently in accordance with 4.3 for the primary mounting axis and for any secondary mounting axis resulting in R_A index (white, primary) and R_A index (white, secondary).

For other signal colours of the same material, including other versions of white created for instance by use of protective coatings, the R_A index shall be derived independently in accordance with 4.3 for the primary mounting axis resulting in R_A index (signal colour, primary).

The R_A index for a secondary mounting axis may also be derived independently in accordance with 4.3. However, it is permissible instead to derive the R_A index by means of scaling using the following expression, in order to make substantial savings in the test work:

$$R_A \text{ index (signal colour, secondary)} = F(\text{white}) \times R_A \text{ index (signal colour, primary)}$$
$$\text{where } F(\text{white}) = R_A \text{ index (white, secondary)} / R_A \text{ index (white, primary)}$$

When the manufacturer declares more than one mounting axis, it is permissible to let the smallest R_A index for these mounting axes represent the product performance in case the R_A indices fall into neighbouring retroreflection performance classes. Otherwise the R_A index shall be reported separately for each mounting axis.

When mounting axis reversal symmetry of a material has been established in accordance with A.4, the manufacturer of the material may declare this symmetry, thereby introducing a secondary mounting axis at a rotation of 180° to the primary mounting axis. In these cases, the test in A.4 needs to be carried out for white sign face material only. It is permissible to let the R_A index for the primary mounting axis represent the product performance for both mounting axes.

NOTE 1: Mounting axis reversal corresponds to applying the sign face material at 180° from a declared mounting axis. This may enable the sheeting to be used more efficiently, or be for colour matching purposes.

NOTE 2: The option to establish mounting axis reversal symmetry is intended for microprismatic sign face materials.

When rotational symmetry of a material has been established by means of the options explained below, the manufacturer of the material may declare rotational symmetry of the material thereby in principle introducing secondary mounting axes at any rotation.

NOTE 3: Mounting axis rotation corresponds to applying the sign face material with a rotation compared to the normal direction. This may enable the sheeting to be used more efficiently. The consequence is that the sign face material is mounted with a rotation relative to the normal direction on the sign.

One option for rotational symmetry is a material that, when tested in accordance with A.5.1, meets the requirements therein. Testing for rotational symmetry need to be done only for the white sign face material of a family. It is permissible to let the R_A index for the primary mounting axis represent the product performance for all rotations of the material.

NOTE 4: This option to establish mounting axis rotation symmetry is intended for glass beaded sign face materials which use rotationally symmetric optics.

The second option occurs when the material passes the test provided in A.5.2, even when the optical elements do not show complete rotational symmetry. The test in A.5.2 needs to be carried out for a sign face material of the colour white only. The product performance for all rotations of the material shall be represented by the minimum R_A index for mounting axes for those rotations used in the test, refer to A.5.2.

NOTE 5: The second option to establish mounting axis rotation symmetry may be applied for sign face materials of any type of construction.

4.5 Requirements for contrast colours

Contrast colours of a sign face material are specified by means of their contrast values with respect to the signal colour white of the same sign face material.

Contrast colour testing is done only for the primary mounting axis, even if more than one mounting axis is declared or symmetries are established.

The contrast color testing may be omitted for materials with clear overlay films (such as dew-resistant and protective overlays that cover both signal and contrast color), provided that the same materials and colors have been tested already without the clear overlay film.

NOTE 1: The contrast between white and a contrast colour is not changed significantly by a clear overlay film. Accordingly it is not necessary to repeat determination of the $R_{A,C}(\alpha,\beta)$ values for contrast colours where clear overlay films are used.

NOTE 2: It is not necessary to calculate the contrast value for non-retroreflective black.

A contrast value is determined as the ratio between an $R_{A,C}(\alpha,\beta)$ value of the contrast colour and an $R_{A,C}(\alpha,\beta)$ value of the signal colour white. The $R_{A,C}(\alpha,\beta)$ values are determined in accordance with annex A. The contrast values shall be determined for the selection of (α,β) cases of the relevant application class; refer to table 3. These contrast values shall all comply with table 5.

A test is valid only for a particular means of obtaining the contrast colour (e.g. inherent colour, use of a coloured overlay film of a particular type or process colour with a particular dye according to a particular procedure) and shall be repeated for other means of obtaining the contrast colour.

Table 5: Permissible ratios between $R_{A,C}(\alpha,\beta)$ values for contrast colours and $R_{A,C}(\alpha,\beta)$ values for the signal colour white

Contrast colour	Ratio	
	Minimum	Maximum
Red	0,12	0,50
Blue	0,03	0,35
Green	0,05	
Dark green	0,03	0,15
Brown	0,015	
Grey	0,40	0,60

4.6 Testing of the retroreflection of sign face materials for factory production control

Retroreflection performance classes for signal colours shall be tested for all performance classes declared by the manufacturer either by the procedure described in 4.2 and 4.3 or by a simplified procedure.

One simplified procedure is to use the method of deriving $R_{A,C}(\alpha,\beta)$ values by simplified testing of A.3 for all sheeting families within a family.

NOTE: This assumes that the proportions $P(\alpha,\beta)$ have been determined previously (e.g. during initial type testing) for the relevant combinations of α and β for the colour white in accordance with A.2.

It is not necessary normally to test the R_A index for secondary mounting axes, nor to retest for mounting axis reversal symmetry nor for rotational symmetry.

Contrasts for contrast colours shall be tested for all performance classes declared by the manufacturer in accordance with 4.5.

5 Daylight luminance factor and chromaticity of retroreflective sign face materials

The luminance factor β and the chromaticity co-ordinates x, y shall be measured using the CIE standard illuminant D65 and the 1931 CIE 2º standard observer in accordance with annex B for all retroreflective sign face materials independently, whether they belong to a family or not.

The luminance factor shall conform to table 6. For chromaticity class CR1, the chromaticity co-ordinates shall conform to the chromaticity boxes provided in table 6. For chromaticity class CR2, the chromaticity co-ordinates shall conform to the chromaticity boxes provided in the relevant table 6 or 7. These chromaticity boxes are illustrated in figures 1 and 2.

A test is valid only for a particular means of obtaining the colour (e.g. inherent colour, use of an overlay film of a particular type or process colour with a particular dye according to a particular procedure) and shall be repeated for other means of obtaining the colour.

NOTE: Class CR1 defines fairly large chromaticity boxes that allow some change of the colours with time and is intended for application over the functional life of a road sign or at least within a specified guarantee period. Class CR2 defines smaller chromaticity boxes and is intended for colour matching and similar purposes, for new materials only.

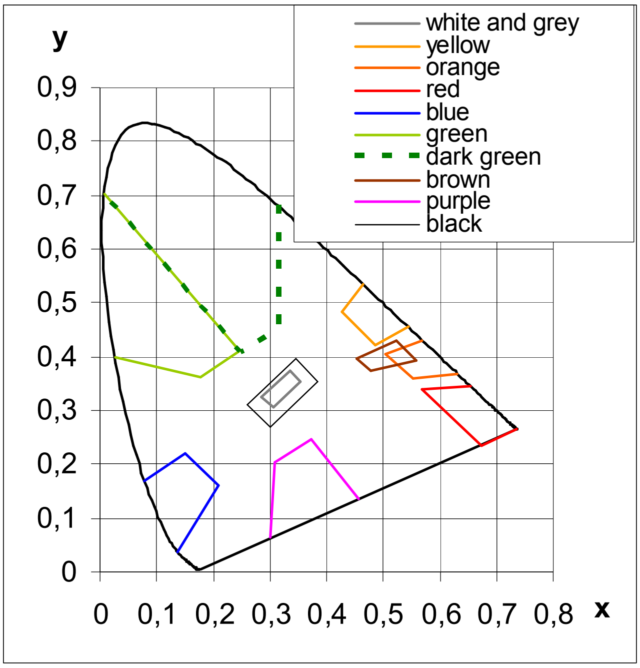
Table 6: Chromaticity boxes for class CR1 and class CR2 for colours not included in table 7

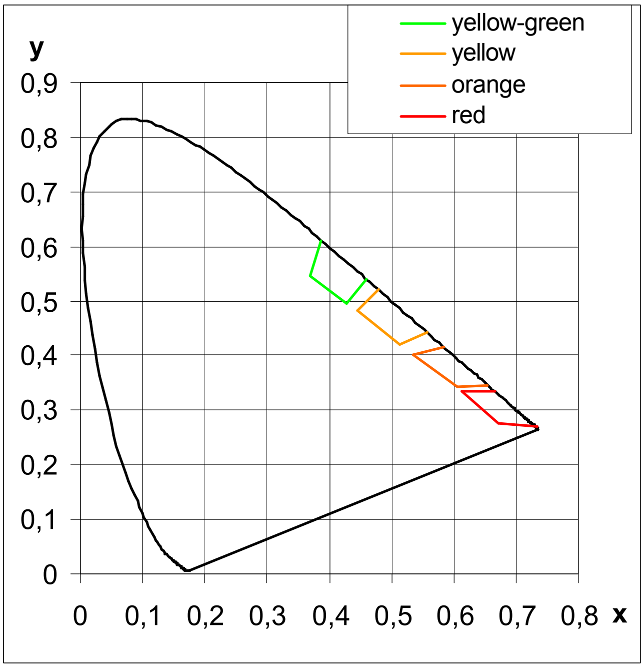
Colour	Point 1		Point 2		Point 3		Point 4		Luminance factor β
	x	y	x	y	x	y	x	y	
Non-fluorescent colours									
White	0,355	0,355	0,305	0,305	0,285	0,325	0,335	0,375	β ≥ 0,27
Yellow	0,545	0,455	0,487	0,423	0,427	0,483	0,465	0,535	β ≥ 0,16
Orange	0,631	0,369	0,552	0,359	0,506	0,404	0,570	0,430	β ≥ 0,12
Red	0,735	0,265	0,674	0,236	0,569	0,341	0,655	0,345	β ≥ 0,030
Blue	0,078	0,171	0,150	0,220	0,210	0,160	0,137	0,038	β ≥ 0,015
Green	0,007	0,703	0,248	0,409	0,177	0,362	0,026	0,399	β ≥ 0,030
Dark green	0,313	0,682	0,313	0,453	0,248	0,409	0,007	0,703	0,070 ≥ β ≥ 0,010
Brown	0,455	0,397	0,479	0,373	0,558	0,394	0,523	0,429	0,090 ≥ β ≥ 0,030
Purple	0,457	0,136	0,374	0,247	0,308	0,203	0,302	0,064	β ≥ 0,020
Grey	0,355	0,355	0,305	0,305	0,285	0,325	0,335	0,375	0,18 ≥ β ≥ 0,11
Non-retroreflective colours									
Black	0,385	0,355	0,300	0,270	0,260	0,310	0,345	0,395	0,030≥ β
Fluorescent colours									
Yellow-green	0,387	0,610	0,369	0,546	0,428	0,496	0,460	0,540	β ≥ 0,60
Yellow	0,479	0,520	0,446	0,483	0,512	0,421	0,557	0,443	β ≥ 0,40
Orange	0,583	0,416	0,535	0,400	0,605	0,343	0,655	0,345	β ≥ 0,20
Red	0,735	0,269	0,671	0,275	0,613	0,333	0,666	0,334	β ≥ 0,15
NOTE 1: When points lie on the spectral boundary, they are joined by that boundary and not by a straight line. NOTE 2: Luminance factor values are rounded to the two nearest decimals, except for the colour blue where they are rounded to the three nearest values.									

Table 7: Chromaticity boxes for class CR2

Colour	Point 1		Point 2		Point 3		Point 4	
	x	y	x	y	x	Y	x	y
White and grey	0,305	0,315	0,335	0,345	0,325	0,355	0,295	0,325
Yellow	0,494	0,506	0,470	0,480	0,513	0,437	0,545	0,455
Red	0,735	0,265	0,700	0,250	0,607	0,343	0,655	0,345
Blue	0,100	0,109	0,146	0,156	0,183	0,115	0,137	0,038
Green	0,007	0,703	0,216	0,448	0,147	0,400	0,018	0,454
Other colours	Refer to Table 7							

NOTE 1: When points lie on the spectral boundary, they are joined by that boundary and not by a straight line.
NOTE 2: Refer to table 6 for luminance factor β





A: Non-fluorescent colours **B: Fluorescent colours**

Figure 1: Chromaticity boxes for class CR1 and class CR2 for colours not included in figure 2.

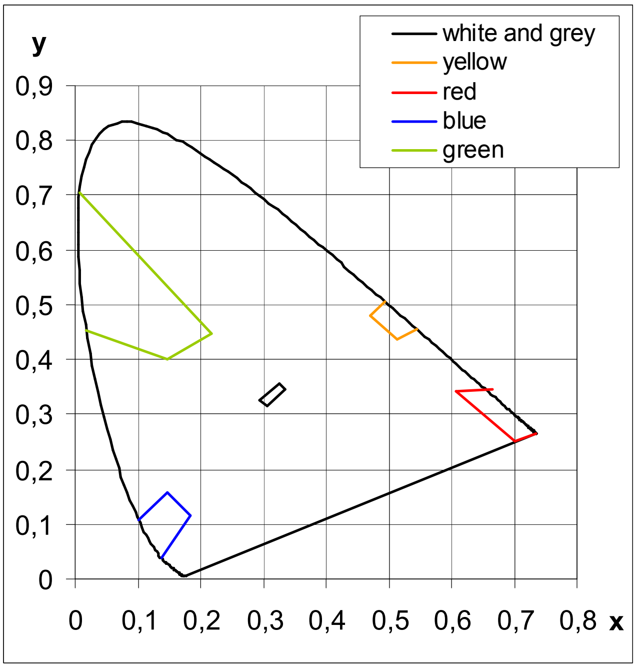


Figure 2: Chromaticity boxes for class CR2

6 Durability

6.1 Resistance to weathering

After weathering in accordance with 6.2 or 6.3, the chromaticity and luminance factor shall conform to the requirements of 5 as appropriate.

For signal colours, R_A values shall be measured before and after weathering at an observation angle (α) of 0,33º and entrance angles (β) of 5° and 30° (β_1 = 5° and 30°, with β_2 = 0° and ε = 0°).

For neither of the two test geometries shall the R_A value differ by more than 15% after weathering as compared with before weathering. In the event that one or both R_A values of a signal colour differ by more than 15% after weathering as compared with before weathering, the R_A index values of that signal colour shall be retested in accordance with 4.3.

For contrast colours, the ratio of the R_A values measured before and after weathering at an observation angle (α) of 0,33º and entrance angles (β) of 5° and 30° (β_1 = 5° and 30°, with β_2 = 0° and ε = 0°) of the contrast colour and the signal colour shall be determined. After weathering, the ratio shall meet the requirements of table 5.

NOTE: To improve the reproducibility of testing, it is recommended that samples are tested before and after weathering using the same equipment.

A test is valid only for a particular means of obtaining the colour (e.g. inherent colour, use of an overlay film of a particular type or process colour with a particular dye according to a particular procedure) and shall be repeated for other means of obtaining the colour.

6.2 Accelerated natural weathering

Samples of material shall be exposed, inclined at an angle of 45° to the horizontal and facing the equator, in accordance with EN ISO 877, Method A for three years.

6.3 Accelerated artificial weathering

The manufacturer may use accelerated artificial weathering to predict durability but testing shall be commenced by accelerated natural weathering not later than the start of the accelerated artificial weathering. The result of accelerated natural weathering shall take precedence over the result of accelerated artificial weathering.

The apparatus shall be either an air-cooled or water-cooled Xenon arc weathering device capable of exposing samples in accordance with EN ISO 4892-2.

Preparation of test specimens shall be in accordance with the general guidelines given in EN ISO 4892-2.

The samples shall be exposed in accordance with EN ISO 4892-2 using the parameters given in Table 8, for a period of 2000 h.

The temperature measurement during accelerated artificial weathering shall correspond to EN ISO 4892-1 and EN ISO 4892-2. Either a black-standard or a black-panel thermometer can be used subject to the thermal conductivity of the substrate of test samples as described in EN ISO 4892-1. The thermometer used shall be stated in the test report. Reflective sheetings are typically appliqued on metallic substrates as e.g. aluminium. In this case the non insulated black panel thermometer shall be used.

Table 8: Accelerated artificial weathering test parameters

Exposure parameters	Air and water cooled lamp
Light/dark/water spray cycle	Continuous light with water spray on specimens for 18 min every 2 h
Black surface temperature during light only periods	(65 ± 3) °C
Relative humidity	(50 ± 5)%
Irradiance (W/m^2) controlled at 340 nm over 300 nm to 400 nm range	 0,51 60
NOTE 1: Water used for specimen spray should contain no more than 1 ppm silica. Higher levels of silica can produce spotting on samples and variability in results. Water of the required purity can be obtained by distillation or by a combination of deionization and reverse osmosis. NOTE 2: Whilst irradiance levels should be set at the above levels, variations in filter ages and transmissivity, and in calibration variations, will generally mean that irradiance error will be in the order of ±10%.	

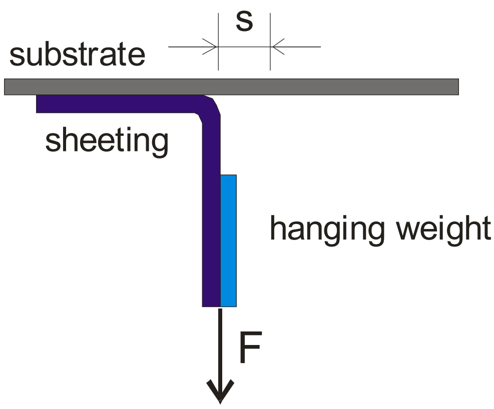
7 Adhesion

A sheeting strip of 25 mm x 150 mm is mounted on a substrate by means of an adhesive as shown in figure 3. After 72 h of drying, a hanging weight with a mass of F = 0,8 Kg is applied to the sheeting strip and the slip s of the sheeting stripe is observed. The slip shall be not exceed 50 mm during the following 5 minutes.

The test is valid only for a particular substrate material and a family of retroreflective sign face materials with identical adhesive and shall be repeated for other substrate materials or adhesives.

Note: The adhesion test is further described in UNE 135340 “Vertical signs. Level III microprismatic polymeric retroreflecting sheetings characteristics and test methods”.

Test method:



Testing Conditions:

Sheeting strip of 25 mm x 150 mm

F = 0,8 Kg / 25 mm

t = 5 minutes

Drying time before testing: 72h

Requirement: s < 50 mm

Figure 3: Adhesion test.

Annex A (normative)

Methods for deriving the coefficient of retroreflection R_A and its symmetries

A.1 General

The methods supply a calculated value of the coefficient of retroreflection $R_{A,C}(\alpha,\beta)$ for a combination of the observation angle α and entrance angle β. Regarding the coefficient of retroreflection R_A and the $R_{A,C}(\alpha,\beta)$ value, refer to 3.3 and 3.4 respectively. The angles α and β and other angles used in the following are defined in CIE 54.2.

Figure A.1 illustrates the angles α and β, and also the rotation angle ε and the orientation angle ω_S.

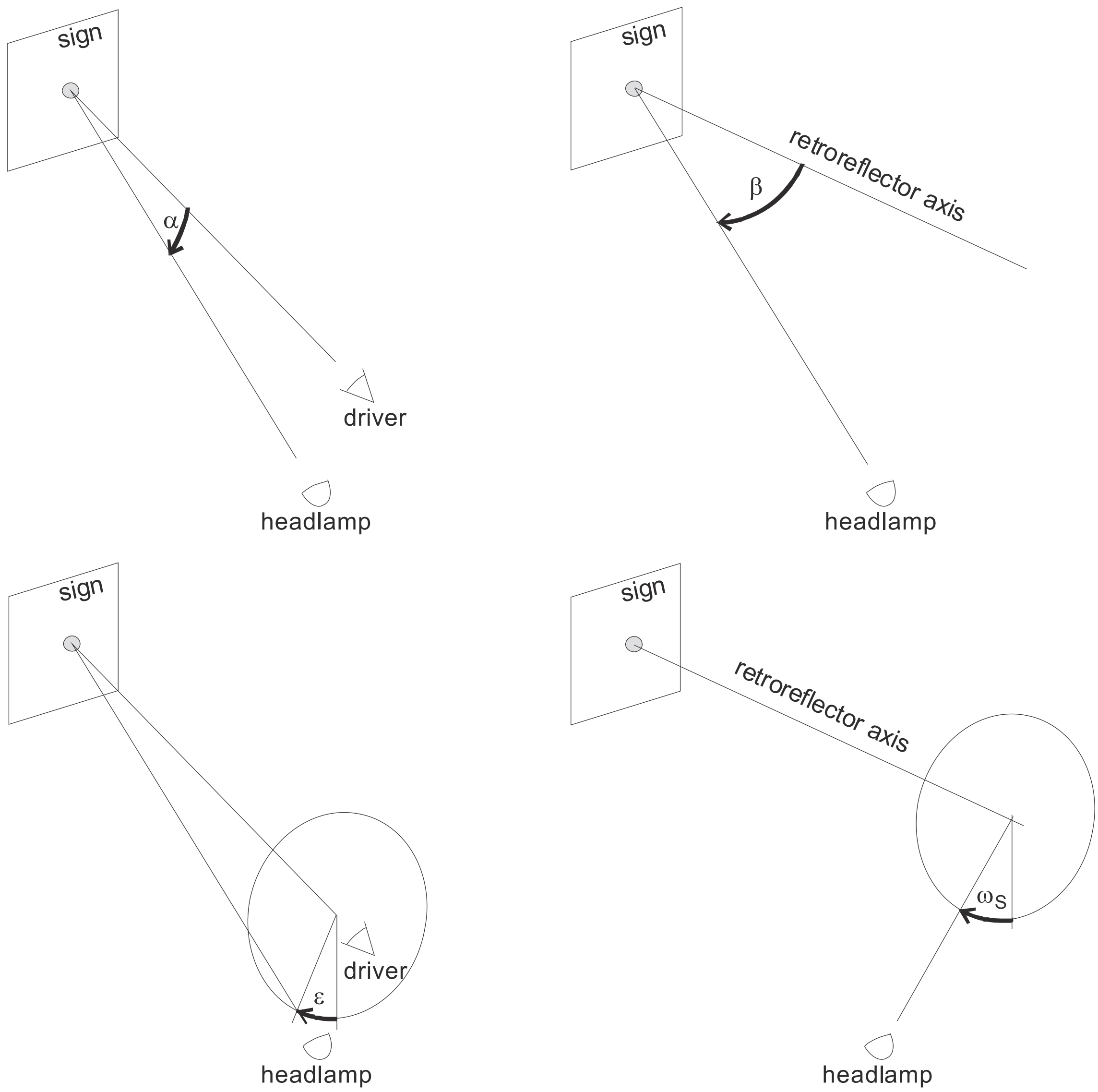


Figure A.1: Illustration of the angles α, β, ε and ω_S

One method, which requires thorough testing, is detailed in A.2. Another method, which requires less thorough testing, is supplied in A.3.

When a family of sign face materials is to be tested, the method detailed in A.2 shall first be used for the colour white. Other sign face materials of this family may be tested by this method (A.2) or by the method detailed in A.3, which has reduced testing requirements. Refer to 3.9 for a definition of a family of sign face materials.

R_A values shall be measured in accordance with CIE 54.2 with aperture angles of the light source and the photometer of 6 ± 0,5 minutes of arc and based on CIE standard illuminant A as defined in ISO/CIE 10526.

For the purpose of testing, a sign face material is assigned a mounting axis as defined in 3.8. The calculated $R_{A,C}(\alpha,\beta)$ value has relevance only if the sheeting is finally employed with this mounting axis pointing upwards.

The methods include the establishment of mounting axis reversal symmetry and mounting axis rotation symmetry.

Mounting axis reversal symmetry shall be established in accordance with A.4 and mounting axis rotation symmetry in accordance with A.5.1 or A.5.2.

When mounting axis reversal symmetry or mounting axis rotation symmetry has been established for a sign face material of the colour white, it can be applied also for other sign face materials of the same family without further testing.

A.2 Method for deriving $R_{A,C}(\alpha,\beta)$ values by thorough testing

This method is applicable for any sign face material, but is in particular intended for the colour white.

For a particular combination of the observation angle α and entrance angle β, the R_A values are measured for a number of cases that are specified in table A.1 by means of the rotation angle ε and the orientation angle ω_s. This table is interpreted in table A.2 for some specific values of α and β. The angles α and β and other angles used in the following are defined in CIE 54.2.

Additionally, $R_A(\alpha,\beta,\varepsilon=0°,\omega_S=0°)$ is measured for the relevant combination of α and β whenever this particular R_A value is not measured as part of the above-mentioned test regime.

Table A.1: Cases to be included in thorough testing

β	ε	ω_s				
		-90°	-75°	0°	75°	90°
β≤5° all α values	-45° 0° 45°			× × ×		
5°<β≤15° all α values	-45° 0° 45°	× × ×		× × ×		× × ×
15°<β≤40° and 0,20°≤α≤0,50°	-45° 0° 45°	× × ×				× × ×
15°<β≤40° and 0,50°<α≤2,00°	-45° 0° 45°	× × ×	× × ×		× × ×	× × ×

Table A.2: Cases to be included in thorough testing for some specific values of α and β

β	ε	ω_s				
		-90°	-75°	0°	75°	90°
β = 5° all α values	-45° 0° 45°			× × ×		
β = 15° all α values	-45° 0° 45°	× × ×		× × ×		× × ×
β = 30° or 40° and α = 0,20° or 0,33° or 0,50°	-45° 0° 45°	× × ×				× × ×
β = 30° or 40° and α = 0,70° or 1,00° or 1,50° or 2,00°	-45° 0° 45°	× × ×	× × ×		× × ×	× × ×

The $R_{A,C}(\alpha,\beta)$ value is calculated from the measured R_A values in the following two steps:

I For each case of ω_s, there are three cases of ε (-45°, 0° or 45°) each with its own measured R_A value. Calculate the average of these three measured R_A values.

II: The smallest of these average R_A values for each case of ω_s is selected. This is the calculated $R_{A,C}(\alpha,\beta)$ value.

EXAMPLE: The table shows an example of measured R_A values ($cd \cdot lx^{-1} \cdot m^{-2}$) for α = 2,0° and β = 15° and the calculation of an $R_{A,C}(\alpha,\beta)$ value in two steps.

ε	ω_s					
	-90°	-75°	0°	75°	90°	
	Measured R_A values					
-45° 0° 45°	7,9 8,8 10,0		7,8 8,4 12,6		8,4 7,6 11,4	Step II: Selection of the smallest R_A value = $R_{A,C}(\alpha,\beta)$
Step I: Calculation of average R_A values	8,9		9,6		9,1	8,9

A value of ω_s has in practice to be set by means of the components β_1 and β_2 of the entrance angle β. The values of β_1 and β_2 may be determined by $\beta_1 = \arcsin(\sin\beta \cdot \cos(\omega_s - \varepsilon))$ and $\beta_2 = \arctan(\tan\beta \cdot \sin(\omega_s - \varepsilon))$. Some frequently used values are supplied in table A.3.

Table A.3: Composition of β by its components β_1 and β_2

β	ε	Components of β	ω_S				
			-90°	-75°	0°	75°	90°
β=5°	-45°	β_1 β_2			3,5° 3,5°		
	0°	β_1 β_2			5,0° 0,0°		
	45°	β_1 β_2			3,5° -3,5°		
β=15°	-45°	β_1 β_2	10,5° -10,7°		10,5° 10,7°		-10,5° 10,7°
	0°	β_1 β_2	0,0° -15,0°		15,0° 0,0°		0,0° 15,0°
	45°	β_1 β_2	-10,5° -10,7°		10,5° -10,7°		10,5° 10,7°
β=30°	-45°	β_1 β_2	20,7° -22,2°	25,7° -16,1°		-14,5° 26,6°	-20,7° 22,2°
	0°	β_1 β_2	0,0° -30,0°	7,4° -29,1°		7,4° 29,1°	0,0° 30,0°
	45°	β_1 β_2	-20,7° -22,2°	-14,5° -26,6°		25,7° 16,1°	20,7° 22,2°
β=40°	-45°	β_1 β_2	27,0° -30,7°	33,8° -22,8°		-18,7° 36,0°	-27,0° 30,7°
	0°	β_1 β_2	0,0° -40,0°	9,6° -39,0°		9,6° 39,0°	0,0° 40,0°
	45°	β_1 β_2	-27,0° -30,7°	-18,7° -36,0°		33,8° 22,8°	27,0° 30,7°

At the end of the test, the proportion $P(\alpha,\beta) = R_{A,C}(\alpha,\beta)/R_A(\alpha,\beta,\varepsilon=0°,\omega_S=0°)$ is calculated for use with the method of A.3.

A.3 Method of deriving $R_{A,C}(\alpha,\beta)$ values by simplified testing

This method is applicable for a sign face material when the white colour of the same family has already been tested in accordance with the method of A.2.

For the particular sign face material, the $R_A(\alpha,\beta,\varepsilon=0°,\omega_S=0°)$ is measured for the relevant combination of α and β and the $R_{A,C}(\alpha,\beta)$ is determined as $P(\alpha,\beta)\times R_A(\alpha,\beta,\varepsilon=0°,\omega_S=0°)$ where $P(\alpha,\beta)$ is the proportion determined for the same combination of α and β for the colour white in accordance with A.2.

NOTE: This method is based on the assumption that the proportion $P(\alpha,\beta)$ is approximately the same for all sign face materials of the same family, as determined mainly by the optical design of the sheeting. The proportion will usually, but not always, be less than unity.

A.4 Establishment of mounting axis reversal symmetry

Mounting axis reversal means the assignment of a secondary mounting axis 180° opposed to the original one.

The method to establish mounting axis reversal symmetry is applicable for sign face materials of any colour, but is in particular intended for the colour white.

Establishment of mounting axis reversal symmetry requires that:

1. the symmetry of the construction of the sign face material is verified and declared by the manufacturer
2. the symmetry is confirmed by test measurements.

The symmetry of the construction of the sign face material requires either that the individual optical elements or otherwise groups (typically, pairs) of optical elements have 180° rotational symmetry and that the distribution of elements or groups also have 180° rotational symmetry.

Measurements for the confirmation shall be carried out at the largest relevant values of α and β depending on the highest application class declared.

EXAMPLE: For application class A34, these are α = 2° and β = 40°. If the manufacturer declares the product only up to application class A22, this would be α = 1.5° and β = 15°.

The average R_A values are to be obtained for each of the relevant cases of ω_s in step I of the method of A.2 (in the case of α = 2° and β = 15°, this is 90°, 0° and 90°), both before and after mounting axis reversal. The cases of the rotation angle ε are to be understood as rotations relative to the current mounting axis.

An average R_A value obtained before mounting axis reversal is compared to the average R_A value for the same case of ω_s obtained after the mounting axis reversal. For all relevant cases of ω_s, these average R_A values must not deviate more than 10% from their common average.

A.5 Establishment of mounting axis rotation symmetry

Mounting axis rotation means the assignment of a new mounting axis at an angle to the original one.

The method to establish mounting axis rotation symmetry is applicable for sign face materials of any colour, but is in particular intended for the colour white.

Establishment of mounting axis rotational symmetry requires that the symmetry is confirmed by complying with requirements as given in A.5.1 or A.5.2.

A.5.1 Optical elements with complete rotational symmetry

This option may be applied if the optical elements of the sign face material exhibit complete rotational symmetry.

Measurements for the confirmation shall be carried out at the largest relevant values of α and β depending on the highest application class declared.

EXAMPLE: For application class A34, these are $\alpha = 2°$ and $\beta = 40°$. If the manufacturer declares the product only up to application class A22, this would be $\alpha = 1,5°$ and $\beta = 15°$.

Average R_A values are to be obtained for each of the relevant cases of ω_s in step I of the method of A.2 (e.g. in the case of $\alpha = 1,5°$ and $\beta = 15°$, this is 90°, 0° and 90°), and for rotations of the material relative to the primary mounting axis of 0°, -90°, 90° and 180°.

For all relevant cases of ω_s, the average R_A values (step I in A.2) for the different rotations must not deviate more than 10% from their common average.

A.5.2 Optical elements without complete rotational symmetry

In the general case, in particular if the optical elements of the sign face material do not comply with the symmetry description of A.5.1, a second option to establish mounting axis rotation symmetry is provided.

Measurements shall be carried out at the largest relevant values of α and β depending on the highest application class declared.

EXAMPLE: For application class A34, these are $\alpha = 2°$ and $\beta = 40°$. If the manufacturer declares the product only up to application class A22, this would be $\alpha = 1.5°$ and $\beta = 15°$.

Average R_A values are to be obtained for each of the relevant cases of ω_s in step I of the method of A.2 (e.g. in the case of $\alpha = 1.5°$ and $\beta = 15°$, this is 90°, 0° and 90°), and for a number of rotations of the material relative to the primary mounting axis.

These rotations shall be 0°, 5°, 8°, 15°, 25°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°, 165°, 180°, 195°, 210°, 225°, 240°, 255°, 270°, 285°, 300°, 315°, 330° and 345°. If mounting axis reversal symmetry has been established for the sign face material, the rotations can be 0°, 5°, 8°, 15°, 25°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150° and 165°.

For all relevant cases of ω_s, the average R_A values (step I in A.2) for the different rotations must not deviate more than 15% from their common average.

Annex B (normative)

Colorimetric testing

B.1 Luminance factor and chromaticity of non-fluorescent materials

B.1.1 General

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

The CIE 45°:0° (or 0°:45°) geometry is adequate for glass beaded sign face materials.

Microprismatic sign face materials show the phenomenon of 'flares' or 'sparkles', which might influence the measured results unless special precautions are taken. A reference method, using the wider apertures of the CIE 45°a:0° (or 0°:45°a) geometry is introduced in B.1.2, while a secondary method using the CIE 45°:0° geometry is introduced in B.1.3.

NOTE: 'Flares' or 'sparkles' are caused by characteristic paths of rays that enter and leave the sheeting surface at different angles. A characteristic path will dominate by raising the luminance factor value significantly and possibly distorting the chromaticity co-ordinates if it is included within narrow beams of illumination and measurement. However, the average contribution to the daylight reflection is small (unless the sign face material is 'metalized').

B.1.2 Reference method for microprismatic sign face materials

Ideally, the measurements shall be made using the CIE 45°a:0° (or 0°:45°a), called the forty-five annular/normal geometry (or the normal/ forty-five annular geometry) defined in CIE 15. The measurement area shall be minimum 1,0 cm^2.
For this geometry CIE 15 recommends that:

- the sampling aperture be irradiated uniformly from all directions between two circular cones with their axes normal to the sampling aperture and apices at the centre of the sampling aperture, the smaller of the cones having a half angle of 40° and the larger of 50°
- the receiver uniformly collects and evaluates all radiation reflected within a cone with its axis on the normal to the sampling aperture, apex at the centre of the sampling aperture, and a half angle of 5°.

The annular geometry can be approximated by the use of a number of light sources in a ring or a number of fibre bundles illuminated by a single source and terminated in a ring to obtain the CIE 45°c:0° (circumferential/normal geometry).

An alternative manner of approximation is to use a single light source, but rotate the sample during measurement with a rotational speed that ensures that a number of revolutions takes place during the exposure time interval for a measurement so that all wavelengths are given equal weight.

In addition, the apertures of the light source and the receiver must have sufficient dimensions in proportion to distances to ensure a reasonable compliance with the above-mentioned recommendations.

NOTE 1: In practice the recommendations can be approximated only. The important issue is that the annular principle is applied and that illumination and collection occur in directions forming fairly large solid angles, as this will reduce the influence of the above-mentioned ‘sparkles’ of microprismatic sign face materials and of other variations with the precise geometry shown by some of these materials.

NOTE 2: In spite of such precautions, the practical difficulties of establishing the annular geometry in accordance with the recommendations introduce uncertainty of measurement.

B.1.3 Secondary method for microprismatic sign face materials

Measurements are performed in the CIE 45°:0° geometry, but shall be normalized for each type and colour of microprismatic sign face material by means of samples of the same type and colour measured by the reference method.

B.2 Luminance factor and chromaticity of fluorescent materials

Measurements shall be made as stated in clause B.1, using an instrument whose source accurately simulates CIE standard illuminant D65.

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 ±15% of that obtained with ideal instrumentation having D65 illumination. The non-retroreflective fluorescent specimen shall incorporate the same colorants as the retroreflective fluorescent specimen.

NOTE: The source may simulate the CIE standard illuminant D65 by means of a monochromator whose output illumination is set in wavelength bands of 10 nm in steps from 300 nm up to 780 nm.

Annex C (informative)

Guidelines for the selection of application and retroreflection performance classes

C.1 Introduction

Drivers need time to read a road sign, ranging from one to several seconds depending on the type and the amount of information displayed on the sign. There is a point where reading must stop - either because the driver has come too close to read the sign without unduly averting his eyes or because he must now react to it. In order to have sufficient reading time available, therefore, the driver must be able to start reading the sign at a distance that varies with the driving speed. The reading time, and hence this distance, depends on the size of symbols and height of letters, to some degree on the contrast in colour between symbol/letters and their background, and on the luminance of letters/symbols or background, whichever is the brighter.

The sections which follow address application classes, representing typical geometrical conditions (C.2), and retroreflection performance classes, representing levels of retroreflection (C.3). These classes are based on certain assumptions regarding the vehicle and headlamp type and the sign position. Other vehicles are considered in C.4, other sign positions in C.5 and other factors in C.6. On this basis, guidelines are provided in C.7.

The descriptions are based on right hand traffic. For left hand traffic the words right and left have to be interchanged in several places in a fairly obvious manner.

C.2 Application classes

The application classes combine distance ranges with cases of the entrance angle of the illumination.

The distance ranges are long, medium and short and are generally applicable for roads with respectively high, medium and low driving speeds.

The distance ranges are: long, 200 m down to 50 m, medium, 120 m down to 40 m; and short, 90 m down to 30 m. They are each represented by five values of the observation angle α, which pertain more to a car than to a truck. These ranges correspond to several seconds of driving at the relevant driving speeds and will normally leave enough time for reading a sign, provided it is legible over the entire range.
The cases of entrance angularity are: narrow, medium, wide and extra wide. They are represented by entrance angles β up to 5°, 15°, 30° and 40° respectively.

The purpose of an application class is to ensure a certain sign luminance level regardless of the distance within the distance range of the class and the entrance angle within the entrance angularity of the class. With regard to distance, some variation of the actual sign luminance with regard to the intended sign luminance level has been allowed.

NOTE: The application classes are based on $R_{A,R}(\alpha,\beta)$ reference values that in themselves correspond to a constant sign luminance of 1 cd/m^2. These values are provided in table 1 and come from the function $R_A = 6{,}99\times\alpha^{-1{,}4}\times\cos\beta$, which has been derived empirically. Variation with regard to distance is permitted by the use of an R_A index during the comparison of actual $R_{A,C}(\alpha,\beta)$ values to $R_{A,R}(\alpha,\beta)$ reference values, refer to 4.2.

High-speed roads are usually comparatively straight and have signs mounted high and/or offset at fairly large distances from the road. This allows for an unobstructed view of signs so that reading can start at a long distance. However, in practice, reading stops at some distance before the sign is actually reached. Signs have sizes of symbols and heights of letters that accommodate reading at large distances. Signs can normally be placed so that entrance angles are relatively small. Two classes are available: A11 and A12 for narrow and medium entrance angularity respectively.

Medium-speed roads could be major all-purpose roads in rural conditions or wide roads in urban conditions. The distances where reading must start and stop are shorter than for a high-speed road. Symbols and letters are also smaller. For some signs it might not be possible to avoid entrance angles exceeding the normal range. Four classes are available: A21, A22, A23 and A24 for narrow, medium, wide and extra wide entrance angularity respectively.

Low-speed roads are typically minor traffic roads in urban conditions or roundabouts on otherwise high-speed roads. The distances where reading must start and stop are relatively short. Symbols and letters can be relatively small. For some signs it could be necessary to accept that entrance angles will be large. Four classes are available, A31, A32, A33 and A34 for narrow, medium, wide and extra wide entrance angularity respectively.

C.3 Retroreflection performance classes

A retroreflective sign face material of a signal colour will supply a nominal luminance numerically equal to its R_A index. The nominal luminance applies for the driver of a passenger car with low beam headlamps matching the 50th percentile European car of UMTRI-2003-37 and to a sign with its centre at a height of 2,5 m and 5 m to the right of the centre of the car.

This luminance will be available under the conditions of the application class. The luminance need not be constant at the nominal luminance, but may vary with the distance and/or the entrance angle. However, the luminance cannot be much lower than the nominal luminance, and will usually be at least equal to the nominal luminance.

Accordingly, a retroreflective sign face material of a signal colour in the retroreflection performance classes P1 to P8 will in most situations supply at least the nominal luminance indicated by the minimum R_A indices of the classes as shown in table 4.

For the signal colour white, the minimum R_A indices of the classes range from 1,4 to 16,0.

In terms of legibility of signs, and also other performance measures such as conspicuity and colour recognition, a luminance of 1,4 cd/m^2 corresponds to inadequate performance bordering on non-performance. The highest luminance of 16,0 cd/m^2 corresponds to much better performance, but still with a legibility which is reduced compared to daylight conditions or some illuminated signs.

For the signal colours yellow, fluorescent yellow or fluorescent yellow/green, the minimum R_A indices of the classes are approximately 30% lower than those for the signal colour white. Use of these signal colours instead of white results in a slight reduction in performance.

The retroreflection performance classes all correspond to sub-optimum conditions. The reason that the classification has not been extended into the range of optimum conditions is that retroreflective sign face materials do not provide such R_A indices. The higher R_A indices of the retroreflection performance classification cannot even be obtained in all the circumstances described in the application classes. This applies in particular for the short distance range and for wide and extra wide entrance angularity.

C.4 Vehicles other than the passenger car

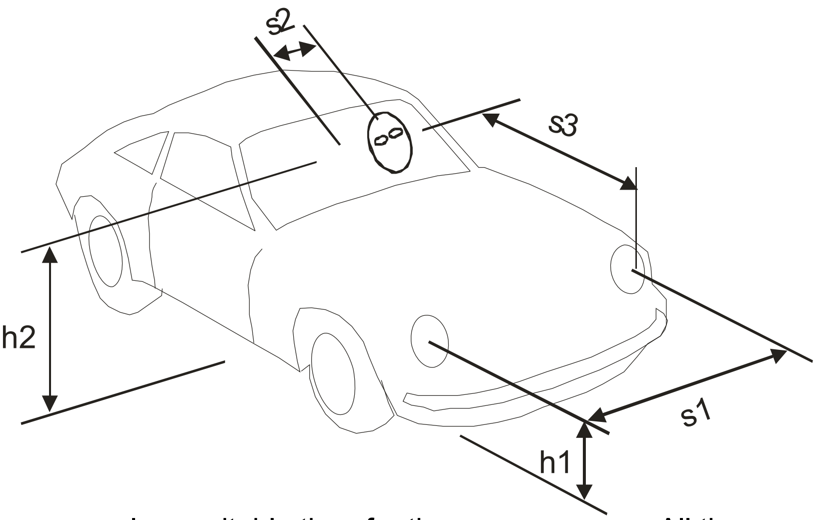
The distance ranges of the application classes are not defined directly in terms of distances, but indirectly in terms of the observation angle α. This means that the actual distance range depends on the geometrical situation, in particular on the geometry of the vehicle.

Two vehicles are used to illustrate this dependence, the passenger car considered in the previous clauses and a large vehicle. The dimensions are provided in table C.1 and illustrated in figure C.1.

Table C.1: The geometry of two vehicles

Geometry of:	h1	h2	s1	s2	s3
Passenger car Large vehicle	0,65 m 0,80 m	1,20 m 2,20 m	1,00 m 1,80 m	0,30 m 0,70 m	2,00 m 0,95 m
h1: height of headlamps above the road h2: height of driver's eyes above the road s1: distance between headlamps s2: transverse distance of eyes from the centre of the vehicle s3: distance of eyes behind headlamp(s)					

Figure C.1: Dimensions used to describe vehicles



For the large vehicle, the distance ranges are less suitable than for the passenger car. All the distances defining the ranges are approximately twice those listed for the passenger car in C.2, for instance 400 m down to 100 m instead of 200 m down to 50 m for the long distance range. However, the reading might not start at longer distances than for the passenger car, because the driver's view of the sign may be obstructed and/or because the size of symbols and the height of the legend are likely to be too small to allow this. The truncation of the ranges at the short ends is real, on the other hand, so that the useful ranges for reading become shorter than for the passenger car.

Therefore, unless the driver of a large vehicle drives much more slowly than the driver of a passenger car, he will have less time - and sometimes insufficient time - available for reading the signs.

Simultaneously, the driver of a large vehicle will have less sign luminance available. This can be seen by comparing the 100 m distance for the large vehicle with the 50 m distance for the passenger car. The R_A values are approximately the same - because the observation angles are approximately the same - but the large vehicle provides less illuminance on the road sign being at the larger distance. As an average for several sign positions, the driver of the large vehicle will see approximately 35% of the sign luminance seen by the driver of the passenger car.

There are vehicles of different types and sizes in between the passenger car and the large vehicle. The drivers of those vehicles experience different degrees of truncation of the useful reading range, and also reduction of the sign luminance.

C.5 Signs at other locations

Figure C.2 shows the headlamp light distribution of the 50th percentile European car of UMTRI-2003-37. It illustrates a number of features:

- signs mounted high receive less light than signs mounted low
- signs to the right receive more light than signs to the left
- signs mounted low to the right receive more light than signs mounted in other positions .

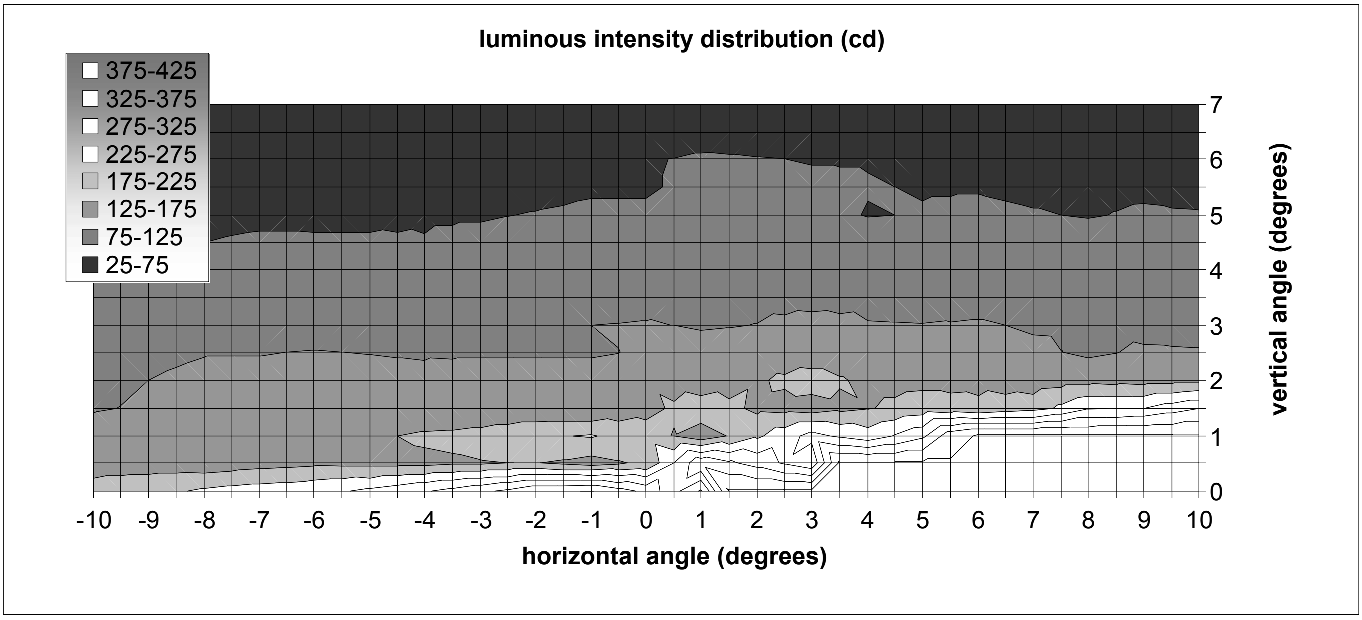


Figure C.2: Light distribution of headlamps

The sign luminance therefore depends on the sign location. The ratios of sign luminances for some sign positions - as derived for the passenger car - are given in table C.2. These will vary as a vehicle approaches the sign, but are approximations that are typical of the ratios likely to be encountered for the specified sign position.

Table C.2: Proportions of sign luminances for some sign positions

Sign mounting and location			Proportion of luminance
Typical mounting	Height above the road	Lateral distance from car axis	
Right shoulder	2,5 m	5,0 m to the right	1,0
Right shoulder	1,0 m	5,0 m to the right	4 to 13 (medium and short range)
Left reserve	2,5 m	9,0 m to the left	0,63
Overhead	6,5 m	directly above	0,47

C.6 Other factors

Several other factors influence the luminance and the legibility of road signs of which some are:

- the condition of the road sign
- the headlamps and their condition
- the windscreen and its condition (transmittance, scattering by wetness and dirt etc.)
- other lights on the vehicle
- other vehicles on the road
- road lighting
- the individual eyesight of the driver

Road signs do show unrecoverable depreciation of the retroreflection during the long periods of time they often serve. Dirt and dew formation can cause strong temporary depreciation.

The headlamp light distribution of the 50th percentile European car of UMTRI-2003-37 is a median light distribution for new and clean headlamps on European cars. The variation of the luminous intensities between headlamps of different types is large, perhaps by a factor of 5 to 10 for directions relevant for road signs.

Headlamps do not stay new and they do not stay clean for very long. Ageing or dirty headlamps can result in more light being scattered upwards. Some data for headlamps in use measured without cleaning indicate that the luminous intensities in directions relevant for road signs are in general more uniform between types of headlamps and significantly higher than for the above-mentioned distribution.

Other lights on the vehicle, in particular marker lights on the top of the cabins of large vehicles, might add significantly to sign luminance.

On busy roads, vehicles going in the same direction assist each other in illuminating signs, resulting in significant increases in the overall sign luminance level.

Vehicles going in the opposite direction can cause considerable glare, in particular on two lane roads, that reduces the legibility of signs.

Road lighting might add some luminance to road signs, but mostly less than 1 cd/m^2.

Drivers have significant variations of eyesight capability. A particular sign luminance might be adequate for some drivers, but not for others.

C.7 Guidelines

It is evident that retroreflection - at least with present technologies - cannot serve to provide road signs with luminance levels that are optimum or even adequate for all drivers in all situations. However, even when this is sub-optimum, the performance of retroflective signs is usually still of some help to drivers. In more difficult cases, or when signs are of utmost importance, the signs have to be directly illuminated. This will often be the case for signs that can be viewed only at short range.

In order to make best use of retroreflection, retroreflective sign face materials should be judged and compared on the basis of their R_A indices for the relevant application as described by the application classes given in table C.3:

Table C.3: Road descriptions for application classes

Class	Reading distance description	Viewing distance	Illumination angle description	Values of entrance angle
A11	Long	200 – 50 m	Narrow	5°
A12			Medium	15°
A13			Wide	30°
A21	Medium	120 – 40 m	Narrow	5°
A22			Medium	15°
A23			Wide	30°
A24			Extra wide	40°
A31	Short	90 – 30 m	Narrow	5°
A32			Medium	15°
A33			Wide	30°
A34			Extra wide	40°

The distance part of the application classes is based on drivers of passenger cars. When priority is given to drivers of large vehicles, for instance when the percentage of large vehicles is high, consideration can be given to using a class for medium distance instead of a class for long distance, or a class for short distance instead of a class for medium distance. Instead of changing from one class to another, both classes can be applied simultaneously, i.e. the material must meet both classes.

Most sign face materials perform less well when they are judged on the basis of wider entrance angularity. Classes of wider entrance angularity should only be applied when such wide angle performance is really necessary, or be applied with a lower retroreflection performance class.

Two or more classes of entrance angularity can be applied simultaneously.

For example: in recognition that the majority of signs are positioned at small entrance angles, the 5° entrance angularity class is applied with a high retroreflection performance class. Simultaneously a lower retroreflection performance class is applied for the 15° and 30° entrance angularity class, as there will probably be some signs viewed at larger entrance angles. This would emphasise the performance requirement for the majority of signs that are positioned at small entrance angles, and still require some level of performance for those signs viewed at wider entrance angles.

The 5° entrance angularity class (A11, A21 and A31) has been introduced in recognition of the above considerations. A11, A21 and A31 classes cannot actually stand alone, as it cannot be ensured in practice that the entrance angle does not exceed 5°. A class of higher entrance angularity must be applied simultaneously.

Figure C.3 might be useful in giving some indication of retroreflection performance versus application class. Suppliers of sign face materials can provide updated and more accurate information. Depending on the application class, a high retroreflection performance class might be met by one product only, or by none at all.

NOTE 1: A1x in figure C.3 means application class A11, A12 or A13 (as appropriate) and similarly for A2x and A3x. Likewise, Ax1 means A11, A21, A31 or A41 (as appropriate) and similarly for Ax2, Ax3 and Ax4.

NOTE 2: The classes of retroreflective performance RA1 and RA2 that were provided in EN 12899-1:2007 represented minimum performance of glass beaded sheeting materials according to two technologies, respectively the enclosed lens and the encapsulated lens. Compared to other technologies, the enclosed lens technology provides its best retroreflection performance at short or medium distance, the encapsulated lens technology at wide or extra wide entrance angularity. Figure C.3 illustrates that the retroreflection performance class is fairly low for this kind of application. The exact retroreflection performance classes cannot be provided as the RA1 and RA2 classes represented minimum performance for a number of products within each of the two technologies with different performance levels.

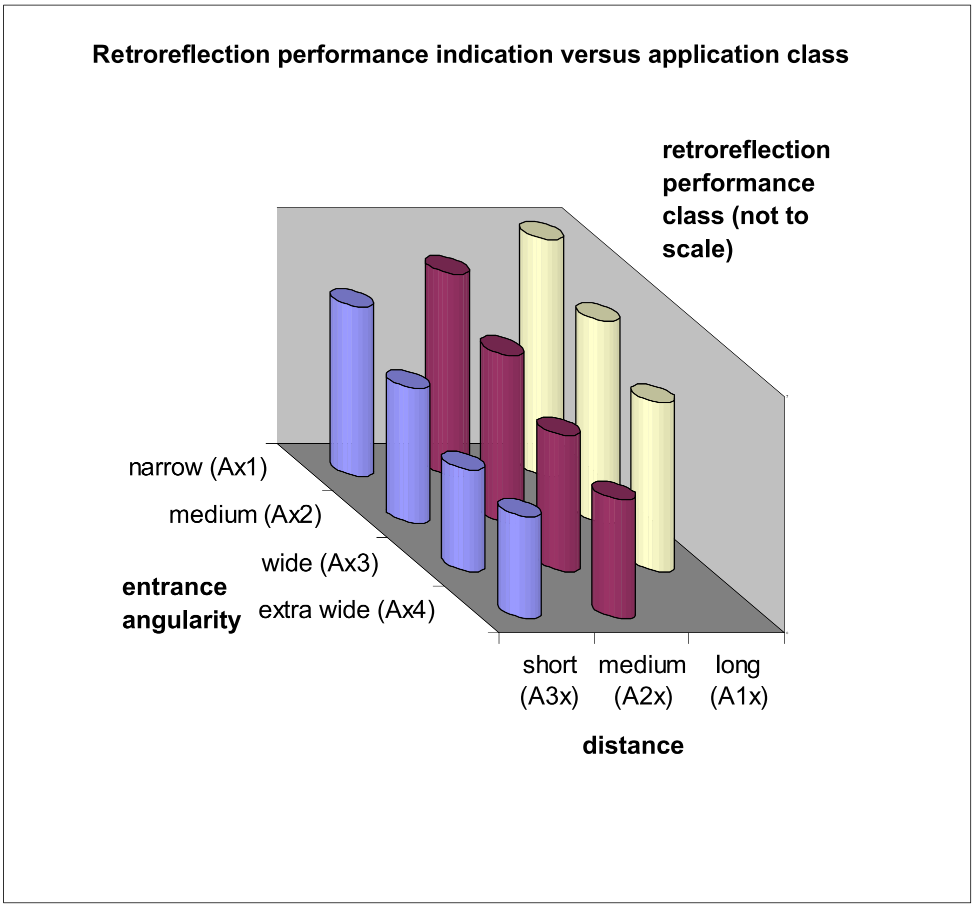


Figure C.3: Retroreflection performance indication versus application class

Some products can actually cover different application classes with high R_A indices. Some products, on the other hand, are best suited for particular applications.

A policy for the selection of retroreflection performance and application classes should be based on suitable considerations, and on compromise. Below are a few practical examples of what parameters can be considered.

A. Balance road sign luminance for different sign positions
Even if road sign luminances obtained by means of retroreflection are normally modest, a policy for retroreflective signs could aim at the balance of road sign luminance for different sign positions, e.g.

- low mounted signs with white as the background colour must not be given a high level of retroreflection
- signs mounted where they receive less light - refer to table C.2 - should have a higher level of retroreflection than other road signs.

The degree to which a balance of luminance can be obtained depends on the sign face materials on the market and on other practical considerations.

B. Performance graduation among road signs of different types
If it is intended to graduate performance levels for road signs of different types, it is recommended to use steps of at least two retroreflection performance classes, as steps of one retroreflection performance class are hardly noticeable (e.g. use P2, P4 and P6 within a road signing policy).

C. Performance selection based on surround luminance
In some countries the brightness of the surroundings of the road are also taken into consideration when selecting the retroreflection performance classes of road signs. The brightness of the surroundings can be divided into three levels labelled low, medium and high using such criteria as presence of road lighting, other types of local lighting (windows, advertising, facades etc), lights on other vehicles, reflection in the road surface, etc.

D. Sign type
In some countries, the performance selection for road signs is also made according to the sign type, e.g. ‘Stop’ signs are typically considered more critical than ‘Parking’ signs and could be given a higher performance level.

E. Practicality
Another practical consideration might for instance be that a particular sign should not be used with sometimes one class of material and sometimes another, as the signs are likely to be mixed up during installation.

Annex D (informative)

Bibliography

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