



Retroreflective materials and devices for road traffic control purposes

Part 1: Retroreflective sheeting



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 - Australian Industry Group
 - Austroads
 - AWTA Product Testing (Testing interests Australia)
 - CIE Australia
 - Council of Textile and Fashion Industries of Australia
 - Department of Planning, Transport and Infrastructure, SA
 - National Association of Testing Authorities Australia
 - New Zealand Road Safety Manufacturers Association
 - New Zealand Transport Agency
 - Roadmarking Industry Association of Australia
 - University of New South Wales
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-

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Australian Standard®

Retroreflective materials and devices for road traffic control purposes

Part 1: Retroreflective sheeting

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PREFACE

This Standard was prepared by the Joint Australia/New Zealand Committee MS-049, Retroreflective Devices, to supersede AS/NZS 1906.1:2007.

This Standard incorporates Amendment No. 1 (January 2020). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

A1

Amendment No. 1 to this Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MS-049, Retroreflective Devices. As a consequence of Amendment No. 1, which is published as an Australian-only amendment, this Standard will be redesignated from AS/NZS 1906.1:2017 to AS 1906.1:2017.

The objective of this Standard is to provide road authorities, manufacturers and testing authorities with a uniform supply specification for retroreflective sheeting.

The objective of this revision is to add a new class of sheeting and change the classification.

This Standard is Part 1 in a series of Standards on retroreflective devices as follows:

AS/NZS

- 1906 Retroreflective materials and devices for road traffic control purposes
- 1906.1 Part 1: Retroreflective sheeting (this Standard)
- 1906.2 Part 2: Retroreflective devices (non-pavement application)
- 1906.3 Part 3: Raised pavement markers (retroreflective and non-retroreflective)
- 1906.4 Part 4: High visibility materials for safety garments

Statements expressed in mandatory terms in notes and/or footnotes to figures and/or tables are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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FOREWORD

The five classes of retroreflective sheeting described in this Standard (Classes 1100, 900, 400, 300 and 100) are principally for use for road traffic signs. Additionally, there is a class for licence plates (Class NP090). Careful consideration should be given as to whether sheeting which conforms with this Standard is appropriate for other applications. For example, the Standard is not applicable to retroreflective sheeting for use on safety garments (refer to AS/NZS 1906.4), or for roadside delineators (refer to AS/NZS 1906.2). This Standard has been written solely as a performance specification for retroreflective sheeting and, with the exception of some advice given in Appendix B, does not give guidance on its use.

This revision of the Standard aims to harmonize its requirements with the photometric performance levels of ASTM D4956-16 *Standard Specification for Retroreflective Sheeting for Traffic Control*, so that performance classes can have improved differentiation between them and their intended uses.

The overall performances of retroreflective sheetings are a combination, and sometimes a compromise, between high performance at narrow observation angles (i.e. the observer is positioned just above the light source—such as in a sedan car) and at wider observation angles (i.e. the observer is positioned further away from the light source—such as a truck driver). This combination can be altered in manufacture by small adjustments to the characteristics of the micro-prisms thus making it possible to optimize retroreflection or sign brightness over a range that best meets the requirements of the driver. The different classes specified within this Standard each have unique performance characteristics and thus will satisfy different road user needs.

Included in this Standard are specifications which will predominately only be fulfilled by micro-prismatic sheeting (Classes 1100, 900 and 400). Users should be aware of some notable differences in the characteristics of this sheeting when compared with sheeting using glass sphere technology (Classes 300 and 100). There can be quite significant changes in photometric performance with changes in rotation angle. This highlights the need to observe manufacturers' orientation marks if sheeting is sensitive to orientation. For sheeting that has performance variation with change in orientation, marking or instructions may be necessary as to the correct orientation of the sheeting in applications such as on traffic signs and to ensure that on any one sign, all pieces of sheeting are orientated in the same direction.

STANDARDS AUSTRALIA

Australian Standard**Retroreflective materials and devices for road traffic control purposes****Part 1: Retroreflective sheeting**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the performance requirements for retroreflective sheeting used in the manufacture of road signs and related traffic control devices. It does not apply to retroreflective pavement markings.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 1580 Paints and related material—Methods of tests
- 1580.408.4 Method 408.4: Adhesion (crosscut)
- 1742 Manual of uniform traffic control devices
- 1742.1 Part 1: General introduction and index of signs

AS/NZS

- 1580 Paints and related materials—Methods of test
- 1580.403.1 Method 403.1: Scratch resistance
- 1906 Retroreflective materials and devices for road traffic control purposes
- 1906.2 Part 2: Retroreflective devices (non-pavement application)
- 1906.4 Part 4: High-visibility materials for safety garments

ISO

- 11664 Colorimetry
- 11664-1 Part 1: CIE standard colorimetric observers
- 11664-2 Part 2: CIE standard illuminants

ISO/IEC

- Guide 98 Uncertainty of measurement
- Guide 98-3 Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

CIE

- 15 Colorimetry
- 20 Recommendations for the Integrated Irradiance and Spectral Distribution of Simulated Solar Radiation for Testing Purposes
- 54.2 Retroreflection: Definition and measurement

ANSI/ISEA

- 107 High-visibility safety apparel and accessories

ASTM	
A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
D2486-06	Standard Test Methods for Scrub Resistance of Wall Paints
D4956-16a	Standard Specification for Retroreflective Sheeting for Traffic Control
FINAT	
FTM 3	Low speed release force*
Austrroads	Guide to Traffic Management

1.3 DESCRIPTION

Retroreflective sheeting can consist of one of the following:

- (a) Very small glass beads enclosed in a thin, transparent, smooth-surfaced plastic matrix, tinted according to the required colour.
- (b) Glass beads encapsulated in a series of cells, the upper surface of which is a transparent film, tinted according to the required colour.
- (c) Very small cube-corner or prismatic elements moulded into the rear face of a clear flexible sheet, tinted according to the required colour (commonly referred to as ‘micro-prismatic sheeting’).

NOTE: These descriptions are not intended to limit the design or method of manufacture provided that the sheeting conforms with the requirements of this Standard.

1.4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.4.1 General terms

1.4.1.1 *Combination fluorescent/retroreflective sheeting*

A sheeting that exhibits fluorescent colour properties in daylight and retroreflective properties under night illumination.

1.4.1.2 *Retroreflective sheeting*

A sheeting that reflects an incident light beam directly back to its source in a narrow cone.

1.4.1.3 May

Indicates the existence of an option.

1.4.1.4 Shall

Indicates that a statement is mandatory.

1.4.1.5 Should

Indicates a recommendation.

1.4.2 Colour

1.4.2.1 *Daylight colour*

The colour observed by daylight with no retroreflective component at the viewing angle.

* FINAT Technical Handbooks may be obtained from the FINAT website:

<http://www.finat.com/Knowledge/FINAT-publications/Technical-Handbook.aspx> [accessed May 2017]

1.4.2.2 Fluorescence

The characteristic of a material to absorb energy from daylight in the shorter wavelength regions of the visible spectrum or in the ultra-violet region, or both, and re-radiate some of this energy at longer wavelengths, producing narrow bands of emission in the visible region with enhanced luminance.

NOTE: The phenomenon can considerably increase the luminance factors, and usually also the purities, of orange and yellow. For yellow, luminance factors exceeding unity may be obtained.

1.4.2.3 Retroreflective colour

The colour of a sheeting observed under retroreflected light using CIE Illuminant A.

1.4.2.4 Process colour

Any method of incorporating colours (defined in this Standard) onto sheeting (post sheeting manufacture) such as using inks or transparent colour overlay.

1.4.3 Forms of physical degradation

1.4.3.1 Blistering

A localized adhesion failure recognizable as one or more raised blisters which may occur in any part of a sample.

1.4.3.2 Corrosion

Discolouration below the surface of the sheeting which results in unsightly daytime appearance and reduced retroreflective performance.

1.4.3.3 Cracking

A failure recognizable as straight and sometimes wide cracks in the sheeting which may be several centimetres long. It is usually the result of embrittlement of the sheeting and is sometimes accompanied by local adhesion failure.

1.4.3.4 Crazing

A failure recognizable as a series of closely spaced small cracks of random length and direction, many of which intersect, which usually indicates the onset of rapid loss of retroreflective properties.

1.4.3.5 Delamination

The separation of individual layers within a sheeting. This may occur as self-delamination whereby layers have separated by themselves without any mechanical intervention during a test or service life, or which may occur as a weakening of the bond between layers to the extent that relatively large pieces of a layer can be peeled away by hand.

1.4.3.6 Edge lifting

A localized adhesion failure recognizable as a lifting and curling of the first few millimetres of sheeting at the edges.

1.4.3.7 Peeling

An adhesion failure which allows the sheeting to peel away in its entirety from the sign panel.

1.4.3.8 Shrinkage (applied)

A reduction in the dimensions of a sheeting noticeable at the edges of an applied sample and measured as the amount by which it has pulled back from its original position at any edge after a period of exposure.

1.4.4 Light technical parameters

1.4.4.1 Coefficient of retroreflection (symbol R_1)

The quotient expressed in candela per lux (cd.lx^{-1}), obtained by dividing the luminous intensity in the direction considered, by the illuminance at the retroreflective surface for given observation, entrance and rotation angles.

NOTE: This coefficient is applicable to devices which are effectively point sources of light at normal viewing distances. It was formerly known as the coefficient of luminous intensity (CIL) and referred to as the 'CIL value'.

1.4.4.2 Specific coefficient of retroreflection (R_A)

The value expressed in candela per lux per square metre ($\text{cd.lx}^{-1}.\text{m}^{-2}$), obtained by dividing the R_1 of a test piece by the area in square metres of that test piece measured parallel to its surface.

NOTE: This coefficient is applicable to retroreflective surfaces of discernible size at normal viewing distances. It was formerly referred to as the 'CIL/ m^2 value'.

1.4.4.3 Illuminance ($E_{\perp T}$) at the retroreflective sheeting

The expression conventionally used to designate the illuminance produced by the source of light and measured in a plane perpendicular to the incident light beam and passing through the centre of the test piece.

1.4.4.4 Luminance factor (β)

The ratio of the luminance of a surface to that of an ideal white diffusing surface when illuminated and viewed under the same conditions and viewing geometry. It is expressed as a decimal in the range 0 to 1 for non-fluorescent colours. It may exceed 1 for fluorescent colours.

1.4.5 Viewing geometry

1.4.5.1 Entrance angle (β)

The angle between the axis normal to the retroreflector through its point of reference and the axis joining the point of reference and the illumination source.

The angle β has two components, β_1 and β_2 as follows:

- (a) β_1 is the component projected onto the plane containing the observation angle.
- (b) β_2 is the component projected onto the plane containing the axis normal to the retroreflector and which is at right angles to the plane containing the observation angle.

NOTES:

- 1 The viewing angles described in Clause 1.4.2 are condensed versions of the corresponding definitions given in CIE 54.2. Reference should be made to CIE 54.2 if a full set of parameters and their definitions is required.
- 2 Since this edition of this Standard specifies that all R_A measurements (except for the rainfall test) are taken in coplanar geometry with the plane containing the entrance angle in the same plane as the observation angle, the R_A values in Section 2 will show $\beta_2 = 0^\circ$.
- 3 For the rainfall test in Appendix E, the R_A measurements are taken in orthogonal geometry with the plane containing the entrance angle at right angles to the plane containing the observation angle. The R_A requirement will show $\beta_1 = 0^\circ$.

1.4.5.2 Observation angle (α)

The angle between the axis joining the point of reference (usually the centre) on the retroreflector (i.e. either the device or the sheeting sample) and the observer or receptor, and the axis joining the point of reference on the retroreflector and the illumination source.

1.4.5.3 *Rotation angle (ε)*

The angle measured from an arbitrary starting point through which the retroreflective sheeting is rotated during the photometric testing, about an axis normal to, and passing through the centre of, the piece (see Figure A1).

1.5 CLASSIFICATION

Retroreflective sheeting is classified according to photometric performance and durability, as follows:

(a) *Class 1100*

Sheeting exhibiting a high level of photometric performance, with both long viewing distance and wide observation angle, as specified in Table 2.1. It has long service durability.

(b) *Class 900*

Sheeting exhibiting an intermediate level of photometric performance, with wide observation angle, as specified in Table 2.2, and long service durability.

(c) *Class 400*

Sheeting exhibiting an intermediate level of photometric performance as specified in Table 2.3, and long service durability.

(d) *Class 300*

Sheeting exhibiting a standard level of photometric performance as specified in Table 2.4 and standard service durability.

(e) *Class 100*

Sheeting exhibiting a basic level of photometric performance, as specified in Table 2.5, and basic service durability.

(f) *Classes NP090 and NP090 (EMB)*

Sheeting exhibiting a basic level of photometric performance as specified in Table 3.1, intended for use on non-embossed and embossed motor vehicle number plates respectively.

(g) *Classes 100T, 300T, 400T, 900T and 1100T*

Sheeting, including flexible variations, exhibiting a photometric performance equivalent to Classes 100, 300, 400, 900 and 1100 respectively designed for applications such as work zone signs and devices typically requiring limited service durability.

SECTION 2 REQUIREMENTS FOR SHEETINGS OTHER THAN FOR NUMBER PLATES

2.1 PHOTOMETRIC PROPERTIES

NOTE: Sheetings for motor vehicle number plates are dealt with in Section 3.

When tested for photometric performance in accordance with Appendix A, a new clean test piece of a given class shall attain a R_A value not less than that specified for the particular class as given in Tables 2.1, 2.2, 2.3, 2.4 or Table 2.5.

This requirement shall apply at each of the entrance and observation angles listed in the tables and for each of the colours listed. The R_A value in each case shall be the mean of the measurements taken at rotation angle $\varepsilon = 0^\circ$ and $\varepsilon = 90^\circ$. Zero rotation angle shall be that indicated by manufacturers' markings on the sheeting or in the absence of such markings, the rotation angle at which the R_A is a minimum, shall be deemed $\varepsilon = 0^\circ$, when measured at $\alpha = 0.2^\circ$ and $\beta_1 = 15^\circ$.

In all photometric specifications and test methods (with the exception of the rainfall test) in this Standard the value β_2 (see Clause 1.4.2.1) shall be zero.

NOTES:

- 1 Micro-prismatic sheeting may exhibit significant variations of performance with changes of rotation angle. It is important therefore that all such sheeting has either orientation markings on its face, or is supplied with instructions as to how it is to be orientated, and that all pieces of sheeting on any one sign are orientated in the same direction. Only pieces of sheeting whose R_A varies by 10% or less with change in rotation angle should be used at different orientations on the one sign face e.g. a diamond warning sign.
- 2 A guide to the minimum desirable luminance contrast ratio between legend and coloured background on a sign having both legend and background reflectorized is given in Appendix B.

2.2 COLOUR

2.2.1 Measurement method

Colour measurement shall be carried out as specified in Appendix C by one of the following methods:

- (a) *The single monochromator method* Except as specified in Item (c), this method shall be used to determine the CIE chromaticity coordinates and total luminance factor of the following:
 - (i) Non-fluorescent sheeting under daylight conditions.
 - (ii) Non-fluorescent and fluorescent sheeting under retroreflected light.
 - (iii) Fluorescent sheeting under daylight conditions subject to the purchaser being satisfied that the resulting measurements lie within the bounds of the CIE colour spaces and the daytime luminance meets visual expectations as well as the specified luminance factor (refer to CIE 20).
- (b) *The double monochromator method* This method shall be used to determine the CIE colour coordinates and total luminance factor of fluorescent sheeting under daytime conditions as a referee method where the purchaser is not satisfied that the results of the single monochromator method accurately reflect the colour performance of the sheeting.
- (c) *The colorimeter method* This method may be used as an alternative to the single monochromator method for the daytime colour and luminance factor measurement of non-fluorescent sheeting.

2.2.2 Performance requirements

When measured in accordance with Clause 2.2.1 the colour of each sheeting shall conform with the following:

- (a) The CIE chromaticity coordinates of a test piece nominated as conforming to a particular colour specified in this Standard shall lie within the colour space defined by the coordinates of the space for that colour—
 - (i) in Table 2.6 for the daylight colour; and
 - (ii) in Table 2.7 for the retroreflective colour.
- (b) The luminance factor of the test piece shall lie within the limits for the corresponding colour in Tables 2.8 and 2.9 for daylight colour only.

The daylight chromaticity coordinates (x , y) and the luminance factor (β) shall be measured in accordance with CIE Publication 15 Colorimetry and shall be calculated from the total spectral radiance factors computed for CIE standard illuminant D65 (refer to ISO 11664-2) for the CIE 1931 (2°) standard colorimetric observer (refer to ISO 11664-1).

TABLE 2.1

MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA FOR CLASS 1100 SHEETING

Entrance angle β_1 ($\beta_2 = 0^\circ$) degrees	Observation angle α degrees	Minimum R_A values $\text{cd.lx}^{-1}.\text{m}^{-2}$											
		Non-fluorescent colours								Fluorescent colours			
		White	Yellow	Red	Dark Green	Blue	Brown	Green (NZ)	Orange	Yellow	Yellow-Green	Orange	Pink*
4	0.2	580	435	87	46	26	17	58	200	350	460	175	116
	0.5	420	315	63	34	19	13	42	150	250	340	125	84
	1.0	120	90	18	10	5.0	4.0	12	42	72	96	36	24
30	0.2	220	165	33	18	10	7.0	22	77	130	180	66	44
	0.5	150	110	23	12	7.0	5.0	15	53	90	120	45	30
	1.0	45	34	7.0	3.6	2.0	1.0	5.0	16	27	36	14	9.0

* Values for pink are for Class 1100T material only [see Clause 1.5(g)].

NOTE: Table 2.1 is reproduced with modification, with permission, from ASTM D4956-16a *Standard Specification for Retroreflective Sheeting for Traffic Control*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

TABLE 2.2
MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA FOR CLASS 900 SHEETING

Entrance angle β_1 ($\beta_2 = 0^\circ$) degrees	Observation angle α degrees	Minimum R_A values $\text{cd.lx}^{-1}.\text{m}^{-2}$											
		Non-fluorescent colours								Fluorescent colours			
		White	Yellow	Red	Dark Green	Blue	Brown	Green (NZ)	Orange	Yellow	Yellow-Green	Orange	Pink†
4	0.2	380	285	76	30	17	11	38	145	230	300	115	76
	0.5	240	180	48	19	11	7.0	24	90	145	190	72	48
	1.0	80	60	16	6.4	3.6	2.4	8.0	30	48	64	24	16
30	0.2	215	162	43	17	10	7.0	22	82	130	170	65	43
	0.5	135	100	27	11	6.0	4.0	14	50	81	110	41	27
	1.0	45	34	9.0	3.6	2.0	1.3	4.5	17	27	36	14	9.0

† Values for pink are for Class 900T material only [see Clause 1.5(g)].

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TABLE 2.3

MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA FOR CLASS 400 SHEETING

Entrance angle β_1 ($\beta_2 = 0^\circ$) degrees	Observation angle α degrees	Minimum R_A values $\text{cd.lx}^{-1}.\text{m}^{-2}$										
		Non-fluorescent colours								Fluorescent colours		
		White	Yellow	Red	Dark Green	Blue	Brown	Green (NZ)	Orange	Yellow	Yellow-Green	Orange
4	0.2	360	270	65	29	30	18	50	145	220	290	105
	0.5	150	110	27	12	13	7.5	21	60	90	120	45
	1.0	35	23	5.0	3.0	2.0	1.0	4.0	12	22	28	11
30	0.2	170	135	30	14	14	8.5	25	68	100	135	50
	0.5	72	54	13	6.0	6.0	3.5	10	28	40	55	22
	1.0	17	11	3.0	2.0	1.0	*	*	6.0	8.5	13	5.0

* Values at these angles are less than $1.0 \text{ cd.lx}^{-1}.\text{m}^{-2}$.

NOTE: Table 2.3 is reproduced with modification, with permission, from ASTM D4956-16a *Standard Specification for Retroreflective Sheeting for Traffic Control*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

TABLE 2.4
MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA FOR CLASS 300 SHEETING

Entrance angle β_1 ($\beta_2 = 0^\circ$) degrees	Observation angle α degrees	Minimum R_A values $\text{cd.lx}^{-1}.\text{m}^{-2}$							
		White	Yellow	Red	Dark Green	Blue	Brown	Green (NZ)	Orange
4	0.2	250	170	45	20	20	12	45	100
	0.5	95	62	15	7.6	7.5	5.0	15	30
	1.0	10	7.0	2.0	1.0	*	*	2.0	4.0
30	0.2	150	100	25	12	11	8.5	25	60
	0.5	65	45	10	5.2	5.0	3.5	10	25
	1.0	9.0	6.0	2.0	*	*	*	2.0	3.0

* Values at these angles are less than $1.0 \text{ cd.lx}^{-1}.\text{m}^{-2}$.

NOTE: Table 2.4 is reproduced with modification, with permission, from ASTM D4956-16a *Standard Specification for Retroreflective Sheeting for Traffic Control*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

TABLE 2.5
MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA
FOR CLASS 100 SHEETING

Entrance angle β_1 ($\beta_2 = 0^\circ$) degrees	Observation angle α degrees	Minimum R_A values cd.lx ⁻¹ .m ⁻²							
		White	Yellow	Red	Dark Green	Blue	Brown	Green (NZ)	Orange
4	0.2	70	50	14	6.0	4.0	1.0	9.0	25
	0.5	30	25	7.5	2.4	2.0	*	4.5	13
	1.0	12	8.0	2.0	1.0	*	*	2.0	5.0
30	0.2	30	22	6.0	2.4	1.7	*	3.5	7.0
	0.5	15	13	3.0	1.2	*	*	2.2	4.0
	1.0	9.0	6.0	1.0	*	*	*	1.0	3.0

* Values at these angles are less than 1.0 cd.lx⁻¹.m⁻².

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TABLE 2.6
CIE CHROMATICITY COORDINATES (x, y) OF THE COLOUR SPACES—
DAYLIGHT ILLUMINATION

Colour designation	Chromaticity coordinates (see Note) CIE 2° Standard observer; CIE Illuminant D65; instrument configuration 45°a:0° or 0°:45°a					
	Non-fluorescent colours					
White	<i>x</i>	0.355	0.305	0.285		0.335
	<i>y</i>	0.355	0.305	0.325		0.375
Red	<i>x</i>	0.649	0.735	0.629		0.565
	<i>y</i>	0.351	0.265	0.281		0.346
Orange	<i>x</i>	0.610	0.535	0.506		0.571
	<i>y</i>	0.390	0.375	0.404		0.429
Brown	<i>x</i>	0.430	0.430	0.550		0.610
	<i>y</i>	0.340	0.390	0.450		0.390
Yellow	<i>x</i>	0.466	0.427	0.487		0.546
	<i>y</i>	0.534	0.483	0.423		0.454
Dark green	<i>x</i>	0.248	0.127	0.313		0.313
	<i>y</i>	0.409	0.557	0.682		0.453
Green (NZ)	<i>x</i>	0.007	0.248	0.177		0.026
	<i>y</i>	0.703	0.409	0.362		0.399
Blue	<i>x</i>	0.137	0.210	0.150		0.078
	<i>y</i>	0.038	0.160	0.220		0.171
Fluorescent colours						
Fluorescent orange	<i>x</i>	0.583	0.535	0.595		0.645
	<i>y</i>	0.416	0.400	0.351		0.355
Fluorescent pink	<i>x</i>	0.600	0.450	0.430	0.536	0.644
	<i>y</i>	0.340	0.332	0.275	0.230	0.290
Fluorescent yellow	<i>x</i>	0.479	0.446	0.512		0.557
	<i>y</i>	0.520	0.483	0.421		0.442
Fluorescent yellow-green	<i>x</i>	0.387	0.369	0.428		0.460
	<i>y</i>	0.610	0.546	0.496		0.540

NOTES:

- 1 Plots of these colour spaces on the CIE Chromaticity Chart are shown in Figures D1 and D2.
- 2 Table 2.6 is reproduced with modification, with permission, from ASTM D4956-16a *Standard Specification for Retroreflective Sheeting for Traffic Control*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

TABLE 2.7
CIE CHROMATICITY COORDINATES (x, y) OF THE COLOUR SPACES—
RETROREFLECTIVE ILLUMINATION

Colour designation	Chromaticity coordinates (see Note) CIE 2° Standard Observer; CIE Illuminant A; observation angle $\alpha = 0,33^\circ$; entrance angle $\beta_1 = 5^\circ$; $\beta_2 = 0^\circ$					
	Non-fluorescent colours					
White	x	0.475	0.360	0.392		0.515
	y	0.452	0.415	0.370		0.409
Red	x	0.652	0.620	0.712		0.735
	y	0.348	0.348	0.255		0.265
Orange	x	0.595	0.565	0.613		0.645
	y	0.405	0.405	0.355		0.355
Brown	x	0.595	0.540	0.570		0.643
	y	0.405	0.405	0.365		0.355
Yellow	x	0.513	0.500	0.545		0.575
	y	0.487	0.470	0.425		0.425
Dark green	x	0.007	0.200	0.322		0.193
	y	0.570	0.500	0.590		0.782
Green (NZ)	x	0.007	0.200	0.322		0.193
	y	0.570	0.500	0.590		0.782
Blue	x	0.033	0.180	0.230		0.091
	y	0.370	0.370	0.240		0.133
Fluorescent colours						
Fluorescent orange	x	0.670	0.635	0.590		0.625
	y	0.330	0.330	0.375		0.375
Fluorescent pink	x	0.600	0.450	0.430	0.536	0.644
	y	0.340	0.332	0.275	0.230	0.290
Fluorescent yellow	x	0.610	0.570	0.528		0.555
	y	0.390	0.395	0.437		0.445
Fluorescent yellow-green	x	0.550	0.523	0.475		0.480
	y	0.450	0.442	0.490		0.520

NOTES:

- 1 Plots of these colour spaces on the CIE Chromaticity Chart are shown in Figures D3 and D4.
- 2 Table 2.7 is reproduced with modification, with permission, from ASTM D4956-16a Standard Specification for Retroreflective Sheeting for Traffic Control, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

TABLE 2.8
LUMINANCE FACTOR (β)—NON-FLUORESCENT SHEETING
DAYTIME ILLUMINATION
(CIE 2° Standard observer; CIE Illuminant D65; instrument
configuration 45°a:0° or 0°:45°a)

Colour designation	Minimum	Maximum
White	0.27	*
Yellow	0.15	0.45
Red	0.025	0.15
Dark green	0.01	0.07
Blue	0.01	0.1
Brown	0.01	0.09
Green (NZ)	0.03	0.12
Orange	0.10	0.30

* Maximum values are not specified for this colour.

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TABLE 2.9
MINIMUM LUMINANCE FACTOR (β_r)—
FLUORESCENT SHEETING
DAYTIME ILLUMINATION
(CIE 2° Standard observer; CIE Illuminant D65;
instrument configuration 45°a:0° or 0°:45°a)

Colour	Total luminance factor (β_r)
Fluorescent orange	0.20
Fluorescent yellow	0.40
Fluorescent yellow-green	0.60
Fluorescent pink	0.25

NOTES:

- 1 This Standard does not specify fluorescent luminance (β_F) as a separate requirement.
- 2 Table 2.9 is reproduced with modification, with permission, from ASTM D4956-16a *Standard Specification for Retroreflective Sheeting for Traffic Control*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

2.3 RAINFALL PERFORMANCE (OPTIONAL)

Where the sheeting is tested for rainfall performance in accordance with Appendix E, the R_A values of the sheeting when measured at entrance angles $\beta_1 = 0^\circ$, $\beta_2 = 4^\circ$ and observation angle $\alpha = 0.2^\circ$ shall not be less than 70% of the corresponding minimum R_A values given in Tables 2.1, 2.2, 2.3, 2.4 or Table 2.5.