AS/NZS 1906.1:2017

Australian/New Zealand Standard

Retroreflective materials and devices for road traffic control purposes

Part 1: Retroreflective sheeting

Superseding AS/NZS 1906.1:2007

AS/NZS 1906.1:2017

This joint Australian/New Zealand standard was prepared by joint Technical Committee MS-049, Retroreflective Devices. It was approved on behalf of the Council of Standards Australia on 10 May 2017 and by the New Zealand Standards Approval Board on 7 June 2017.

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CIE Australia
Council of Textile and Fashion Industries of Australia
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Australian/New Zealand 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.

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/STANDARDS NEW ZEALAND

Australian/New Zealand 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*

Austroads 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.

1.4.2 Colour

1.4.2.1 *Daylight colour*

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

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.

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* FINAT Technical Handbooks may be obtained from the FINAT website:
http://www.finat.com/Knowledge/FINAT-publications/Technical-Handbook.aspx [accessed May 2017]

1.4.2.4 *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_I)*

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 ($cd.lx^{-1}.m^{-2}$), obtained by dividing the R_I 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 $\beta_2 = 0°$.

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 $\beta_1 = 0°$.

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 $\varepsilon = 0°$ and $\varepsilon = 90°$. 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 $\varepsilon = 0°$, when measured at $\alpha = 0.2°$ and $\beta_1 = 15°$.

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 ($\beta_2 = 0°$) degrees	Observation angle α degrees	Minimum R_A values cd.lx^{-1}.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 ($\beta_2 = 0°$) degrees	Observation angle α degrees	Minimum R_A values cd.lx^{-1}.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 ($\beta_2 = 0°$) degrees	Observation angle α degrees	Minimum R_A values cd.lx^{-1}.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 cd.lx^{-1}.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 ($\beta_2 = 0°$) 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	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 cd.lx^{-1}.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 ($\beta_2 = 0°$) 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	*x*	0.355	0.305	0.285	0.335
	y	0.355	0.305	0.325	0.375
Red	*x*	0.649	0.735	0.629	0.565
	y	0.351	0.265	0.281	0.346
Orange	*x*	0.610	0.535	0.506	0.571
	y	0.390	0.375	0.404	0.429
Brown	*x*	0.430	0.430	0.550	0.610
	y	0.340	0.390	0.450	0.390
Yellow	*x*	0.466	0.427	0.487	0.546
	y	0.534	0.483	0.423	0.454
Dark green	*x*	0.248	0.127	0.313	0.313
	y	0.409	0.557	0.682	0.453
Green (NZ)	*x*	0.007	0.248	0.177	0.026
	y	0.703	0.409	0.362	0.399
Blue	*x*	0.137	0.210	0.150	0.078
	y	0.038	0.160	0.220	0.171
Fluorescent colours					
Fluorescent orange	*x*	0.583	0.535	0.595	0.645
	y	0.416	0.400	0.351	0.355
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*	0.479	0.446	0.512	0.557
	y	0.520	0.483	0.421	0.442
Fluorescent yellow-green	*x*	0.387	0.369	0.428	0.460
	y	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 α = 0,33°; entrance angle β_1 = 5°; β_2 = 0°				
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.

NOTE: Table 2.8 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 2.9

MINIMUM LUMINANCE FACTOR (β_T)— 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_T)
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 $\beta_1 = 0°$, $\beta_2 = 4°$ and observation angle $\alpha = 0.2°$ 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.

2.4 PHYSICAL PROPERTIES

2.4.1 Tensile strength and elongation test

When tested in accordance with Appendix F, the breaking strength of the base reflective sheeting shall be not less than 20 N per 25 mm width, and the maximum elongation at break point shall not exceed 45%.

The requirements of this Clause shall not apply to any sheeting which is intended for use without being first applied to a substrate.

NOTE: No minimum elongation is specified (except for Class NP090 (EMB) sheeting, see Section 3).

2.4.2 Impact test

This test is not a requirement for non-adhesive backed retroreflective sheetings.

All classes of sheeting are required to comply with the requirements of the impact test specified in this Clause.

When the sheeting is tested in accordance with Appendix F, the domed area formed by the impact shall show no evidence of cracking, crazing, or lifting of the sheeting from the test panel.

2.4.3 Scratch resistance test for factory-coloured and overlay-coloured films

When tested in accordance with Appendix F, the sheeting shall have a scratch resistance greater than 1.5 kg.

This test is not a requirement for non-adhesive backed retroreflective sheetings.

2.4.4 Adhesion cross cut test for screen printed colours

Process colours not covered by a laminate shall have an adhesion rating of 3 or better when tested according to the cross cut adhesion test of AS 1580.408.4.

This test is not a requirement for non-adhesive backed retroreflective sheetings.

2.4.5 Solvent resistance for factory-coloured and overlay-coloured films

When tested in accordance with Appendix G the retained daylight colour and luminance factors shall remain within the limits set out in Tables 2.6, 2.8 and 2.9, as appropriate for all solvents.

For white sheeting only, the retained R_A values at $\alpha = 0.2°$ and $\beta_1 = 4°$, $\beta_2 = 0°$ shall not be less than 80% of the corresponding values given in Tables 2.1, 2.2, 2.3, 2.4 and 2.5. Moreover, the sample shall not show any other deterioration such as softening or dissolving of the surface or the total removal of the surface material.

2.5 ADHESIVE

2.5.1 Application

The following shall apply to all retroreflective sheeting designed to be applied to a substrate.

Retroreflective sheeting shall be pre-coated with a pressure sensitive adhesive. The pre-coated adhesive shall be such that no further application of adhesive is necessary. The manufacturer of the sheeting shall supply instructions for its application in sufficient detail to ensure that the adhesive performance requirements can be met when the sheeting is applied in accordance with such instructions.

2.5.2 Adhesive bond

The adhesive shall form a durable bond to smooth, corrosion-resistant and weather-resistant surfaces, shall have no staining effects, and shall be mildew-resistant. It shall securely bond the retroreflective sheeting to the substrate, and conform with the following requirements:

(a) When the sheeting is tested in accordance with Appendix H, the adhesive limit of the dry sheeting shall be not less than 6 N per 25 mm width.

(b) If the sheeting breaks before peeling, but has passed the tensile test requirement specified in Appendix F, it shall be considered satisfactory.

2.5.3 Protective liner

The sheeting shall be supplied with a liner to protect the adhesive surface. The liner shall be readily removable by peeling, without soaking in water or in solvents, and without tearing, breaking or removing any of the adhesive from the back of the sheeting.

The liner release performance should be tested in accordance with FINAT Test Method No. 3 FTM 3: *Low speed release force*. The sample should achieve a release value of no greater than 200 cN/25 mm.

2.6 DURABILITY

2.6.1 General

Two separate durability test environments are specified in this Standard as follows:

(a) *Outdoor accelerated weathering test—Fixed rack method*

This test shall be applied to establish acceptance of a new sheeting type or method of manufacture, and for the continuing periodic testing of an accepted type as a check on the maintenance of durability properties.

NOTE: See Clause 2.6.2.

(b) *Outdoor accelerated weathering test—Moving rack method*

Where specified, the test shall be carried out as given in Clause 2.6.2 (outdoor moving rack).

These tests shall not be used to establish acceptance of a new make or type of sheeting, and the results shall be overridden by any adverse long-term or in-service exposure results subsequently obtained.

2.6.2 Outdoor accelerated weathering tests, fixed rack or moving rack

When the sheeting is tested in accordance with Paragraph I2 by the fixed or moving rack method as permitted in Table 2.10, Column 6, and for each class of sheeting, the test piece after receipt of the specified amount of radiant energy, shall conform with the following requirements:

(a) It shall not be removable from the test panel without damage.

(b) It shall not show evidence of cracking, crazing, peeling, blistering or delamination.

(c) It shall not show more than 1 mm applied shrinkage or edge lifting on any edge.

(d) It shall not show edge damage or corrosion extending more than an average of 1 mm, or 4 mm at any one point, into the sheeting from the edge, except that non-functioning of cells in cellular sheeting which have been cut or damaged during preparation of the test piece shall not be grounds for rejection.

(e) It shall have a residual R_A value when tested at an entrance angle $\beta_1 = 4°$, $\beta_2 = 0°$ and observation angle $\alpha = 0.2°$ in accordance with Appendix A, of not less than the percentage shown in Table 2.10, Column 3, of the relevant value in the corresponding reference shown in Table 2.10, Column 4.

(f) In respect of colourfastness, it shall continue to meet all of the requirements of Clause 2.2 including luminance factor.

The moving rack test shall not be used to evaluate the performance of Class 900 fluorescent orange sheeting or any Class T sheeting.

NOTE: The moving rack test is an optional test for other classes [see Clause 2.6.1(b)].

TABLE 2.10

PERFORMANCE REQUIREMENTS AFTER OUTDOOR EXPOSURE

1	2	3	4	5	6
Sheeting Class	**Colour**	**Residual performance %**	**Reference table**	**Radiant energy to be received***	**Permitted test method**
1100	All except fluorescent orange and orange	80	2.1	22 500	Fixed or moving rack†
900	All except fluorescent orange and orange	80	2.2	22 500	Fixed or moving rack†
400	All except fluorescent orange and orange	80	2.3	22 500	Fixed or moving rack†
300	All	80	2.4	22 500	
100	All	50	2.5	15 000	
1100T	All	80	2.1	3 750	Fixed rack only
900T	All	80	2.2	3 750	
400T	All	80	2.3	3 750	
300T	All	80	2.4	3 750	

* It is expected that a fixed rack exposure period of about one year will be required for each 7500 MJ/m^2 received and about 8 months for moving rack exposure.

† The moving rack method is not for use for establishing acceptance of a new material [see Clause 2.6.1(b)].

2.7 PROCESS COLOUR PROPERTIES

2.7.1 General

The sheeting shall be capable of being colour-processed using either compatible transparent and opaque films, screen process colours, and graphic printing inks supplied or recommended by the retroreflective sheeting manufacturer.

2.7.2 Requirements

When processed in accordance with the recommendations of the manufacturer of the retroreflective sheeting, colour processed material shall conform with the following requirements:

(a) Process colour sheeting comprising transparent films or ink imparted colours applied to white retroreflective sheeting when new shall conform to the relevant chromaticity coordinates and luminance values given in Tables 2.6 and 2.7 and to a minimum of—

(i) 80% for ink imparted colours; or

(ii) 100% for coloured transparent film and digital print under clear overlay film

of the R_A values as shown in Tables 2.1, 2.2, 2.3, 2.4 or Table 2.5, for sheeting of corresponding class and colour.

NOTE: If the relevant specific coefficient of retroflection R_A is less than 1.0 cd.lx^{-1}.m^{-2}, this requirement is not applicable.

(b) The physical properties of the base sheeting specified in Clause 2.4 and the rainfall performance specified in Clause 2.3 shall continue to meet the relevant requirements.

(c) The physical properties for any process colour area shall conform with the physical properties of the parent sheeting specified in Clause 2.4.

(d) When subjected to outdoor fixed-rack accelerated weathering testing in accordance with Appendix I, a colour processed sheeting shall conform with the requirements of Clause 2.6.2 and the following:

(i) The film or process colour shall not show any evidence of cracking, crazing, peeling or lifting from the base sheeting.

(ii) In respect of the colourfastness, the sheeting shall continue to meet all of the requirements of Clause 2.2.

NOTE: Outdoor moving rack accelerated weathering test is optional [see Clause 2.6.1(b)].

2.8 PACKAGING

2.8.1 Packaging

The retroreflective sheeting shall be packaged so as to ensure adequate protection against physical damage in storage and transit before delivery.

2.8.2 Splicing of rolls

A roll or length of sheeting shall not contain on average more than one splice per 11 m, so that the sheeting will be suitable for continuous application as supplied. The minimum length between splices and the end of a roll and between successive splices shall be 3 m.

2.9 SHELF LIFE

The sheeting shall be capable of withstanding storage for at least 12 months at the normal store temperatures likely to be encountered, or as otherwise recommended by the manufacturer, without loss of adhesion, flexibility or other specified properties.

2.10 MARKING

Packages containing retroreflective sheeting shall be durably marked with the following information:

(a) The manufacturer’s name or trademark.

(b) Product designation, i.e. colour, identification number, and size of roll or sheet.

(c) Production batch number.

NOTE: Manufacturers making a statement of conformance with this Australian/New Zealand Standard on a product, packaging, or promotional material related to that product are advised to ensure that such conformance is capable of being verified.

2.11 RETROREFLECTIVE SHEETING IDENTIFICATION

Prismatic retroreflective sheetings shall have a durable and visible identification mark. The durability of the mark shall be equivalent to the expected lifetime of the retroreflective sheeting and shall be visible on the finished product. The mark shall contain at least the following information:

(a) Manufacturer’s identification logo or symbol.

(b) Product identification code.

All information shall be consistently repeated at least once within each area of 400 mm × 400 mm.

SECTION 3 SHEETINGS FOR MOTOR VEHICLE NUMBER PLATES—CLASSES NP090 AND NP090 (EMB)

3.1 PHOTOMETRIC PROPERTIES

3.1.1 Photometric performance

When tested for photometric performance in accordance with Appendix A, a new clean test piece of Class NP090 or NP090 (EMB) shall attain a R_A value not less than that specified in Table 3.1 and shall not be greater than 250 $cd.lx^{-1}.m^{-2}$.

This requirement shall apply at each of the entrance and observation angles listed in Table 3.1 for each of the colours listed and at the rotation angle at which the R_A value is a minimum.

TABLE 3.1

MINIMUM COEFFICIENT OF LUMINOUS INTENSITY PER UNIT AREA FOR CLASS NP090 AND CLASS NP090 (EMB) SHEETING

Entrance angle β_1 ($\beta_2 = 0°$) degrees	Observation angle α degrees	Minimum R_A values $cd.lx^{-1}.m^{-2}$		
		White	Yellow	Lemon-yellow
4	0.2	60	40	40
	0.5	26	17	17
	1.0	9.0	6.0	6.0
30	0.2	26	17	17
	0.5	13	8.0	8.0
	1.0	7.0	4.0	4.0

3.1.2 Variation of performance with rotation angle

For any one test piece the R_A value obtained at the rotation angle for which it is a maximum, shall not exceed that at the rotation angle for which it is a minimum by more than 10%, when measured at $\beta_1 = 15°$, $\beta_2 = 0°$ and $\alpha = 0.2°$.

3.2 COLOUR

When tested under simulated daylight illumination and under retroreflective illumination in accordance with Appendix C, 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—

(a) in Table 3.2 for the daylight colour; or

(b) in Table 3.3 for the retroreflective colour.

The luminance factor of the test piece shall lie within the limits for the corresponding colour in Table 3.2 for daylight colour only.

TABLE 3.2

CIE CHROMATICITY COORDINATES (*x*, *y*) AND LUMINANCE FACTOR (β) FOR CLASS NP090 AND CLASS NP090 (EMB)—DAYLIGHT ILLUMINATION

Colour designation	Chromaticity coordinates (CIE 2° Standard observer; CIE illuminant D65; instrument configuration 45°a:0° or 0°:45°a)					Luminance factor (β) minimum
White	*x*	0.355	0.305	0.285	0.335	0.27
	y	0.355	0.305	0.325	0.375	
Yellow	*x*	0.450	0.500	0.560	0.498	0.16
	y	0.460	0.410	0.440	0.502	
Lemon-yellow	*x*	0.395	0.450	0.495	0.423	0.30
	y	0.515	0.460	0.502	0.574	

NOTE: Plots of these colour spaces on the CIE chromaticity chart are shown in Figure D5.

TABLE 3.3

CIE CHROMATICITY COORDINATES (x, y) FOR CLASS NP090 AND CLASS NP090 (EMB)—RETROREFLECTIVE ILLUMINATION

Colour designation	Chromaticity coordinates (CIE 2° Standard observer; CIE Illuminant A; observation angle α = 0.33°; entrance angle β_1 = 5°; β_2 = 0°				
White	*x*	0.475	0.360	0.392	0.515
	y	0.452	0.415	0.370	0.409
Yellow	*x*	0.513	0.500	0.545	0.572
	y	0.487	0.470	0.425	0.425
Lemon-yellow	*x*	0.513	0.500	0.545	0.572
	y	0.487	0.470	0.425	0.425

NOTE: Plots of these colour spaces on the CIE chromaticity chart are shown in Figure D6.

3.3 RAINFALL PERFORMANCE

When the sheeting is tested for rainfall performance in accordance with Appendix E, the R_A values of the sheeting when measured at $\beta_1 = 0°$, $\beta_2 = 4°$ and $\alpha = 0.2°$ shall not be less than 70% of the corresponding minimum R_A values given in Table 3.1.

3.4 PHYSICAL PROPERTIES

3.4.1 Tensile strength and elongation test

When tested in accordance with Appendix F, the breaking strength of the sheeting shall be not less than 20 N per 25 mm width. Elongation limits shall be as follows:

(a) Class NP090—*maximum* elongation 45%.

(b) Class NP090 (EMB)—*minimum* elongation 70%.

3.4.2 Impact test

When the sheeting is tested in accordance with Appendix F, the domed area formed by the impact shall show no evidence of cracking, crazing or lifting of the sheeting from the test panel.

3.4.3 Scrub abrasion test

When subjected to the scrub abrasion test at Appendix F the sheeting shall meet an abrasion evaluation of ‘good’ or better.

3.4.4 Solvent resistance

When tested in accordance with Appendix G using the solvents listed, the retained daylight colour and luminance factors shall remain within the limits set out in Table 3.2.

For white sheeting only, the retained R_A values at $\alpha = 0.2°$, $\beta_1 = 4°$, and $\beta_2 = 0°$ shall not be less than 80% of the corresponding values given in Table 3.1. Moreover, the sample shall not show any other deterioration such as softening or dissolving of the surface or the total removal of the surface material.

3.5 ADHESIVE

Sheeting shall meet all of the requirements of Clause 2.5.

3.6 DURABILITY

When subjected to fixed-rack outdoor exposure testing in accordance with Appendix I, after receipt of a total of 15 000 MJ/m^2 of radiant energy the sheeting shall meet the requirements of Clause 2.6.2, Items (a), (b), (c) and (d), and shall have a residual R_A value when tested at $\alpha = 0.2°$, $\beta_2 = 0°$ and $\beta_1 = 4°$ in accordance with Appendix A of not less than 50% of the corresponding values in Table 3.1.

In respect of colourfastness, it shall continue to meet the requirements of Clause 3.2 including luminance factor.

The moving rack outdoor exposure test may also be used for the purpose described in Clause 2.6.1(b).

3.7 COLOUR-PROCESSING PROPERTIES

3.7.1 General

The sheeting shall be capable of being colour-processed using either compatible transparent or opaque films, roll-coat inks or screen process colours, and graphic printing inks supplied or recommended by the retroreflective sheeting manufacturer for colours defined in Table 3.2 and non-defined colours.

3.7.2 Requirements

When processed in accordance with the recommendations of the manufacturer of the retroreflective material, the films and process colours shall not react adversely with the material and the colour processed material shall conform with the following requirements:

(a) Colour-processed material comprising transparent films or process colours applied to white retroreflective material when new shall conform to the relevant chromaticity coordinates and luminance values given in Tables 3.2 and 3.3 and to a minimum of—

(i) 70% for process colours; or

(ii) 90% for transparent film

of the R_A values as shown in Table 3.1 for material of corresponding class and colour.

NOTE: If the relevant chromaticity coordinates and luminance value is less than 1.0, this requirement is not applicable.

For non-defined colours, retroreflective performance shall meet the relevant jurisdictional requirements.

(b) The physical properties of any colour processed area shall conform with Clause 2.4.4.

(c) The physical properties of the parent material specified in Clause 3.4 and the rainfall performance specified in Clause 3.3 shall not be detrimentally affected.

(d) The physical properties for any colour-processed area shall conform with the physical properties of the parent material specified in Clause 3.4.

NOTE: This requirement includes resistance of the colour-processed areas to solvents.

(e) When subjected to accelerated weathering testing in accordance with Appendix I, a colour processed material shall conform with the requirements of Clause 3.6 and the following:

(i) The film or process colour shall not show any evidence of cracking, crazing, peeling or lifting from the parent material.

(ii) In respect of the colourfastness the material shall continue to meet all of the requirements of Clause 3.2.

3.8 PACKAGING

The retroreflective sheeting shall be packaged so as to ensure adequate protection against physical damage in storage and transit before delivery.

3.9 SHELF LIFE

The sheeting shall be capable of withstanding storage for at least 12 months at the normal store temperatures likely to be encountered, or as otherwise recommended by the manufacturer, without loss of adhesion, flexibility or other specified properties.

3.10 MARKING

Packages containing retroreflective sheeting shall be durably marked with the following information:

(a) The manufacturer’s name or trademark.

(b) Product designation, i.e. colour, identification number, and size of roll or sheet.

(c) Production batch number.

NOTE: Manufacturers making a statement of conformance with this Australian/New Zealand Standard on a product, packaging, or promotional material related to that product are advised to ensure that such conformance is capable of being verified.

APPENDIX A

PHOTOMETRIC PROPERTIES TEST

(Normative)

A1 SCOPE

This Appendix sets out methods for determining the R_A value of retroreflective sheeting.

A2 PRINCIPLE

The light incident on the sample and the light reflected from the sample are measured and the ratio, expressed as luminous intensity per lux per square metre, is the R_A in $cd.lx^{-1}.m^{-2}$.

A3 METHODS

Either of the following two methods may be employed:

(a) *The two detector method*

The illuminance (in lux) at the sample and the luminous intensity (in cd) of the sample are measured using separate detectors.

NOTE: If a luminance detector is used to measure the luminous intensity of the sample, the detector may be calibrated for intensity using a reference intensity lamp.

(b) *The single detector method*

The illuminance at the sample and illuminance from the sample are measured using the same detector but at the different locations.

NOTE: The single detector method has the advantage that, since it is a ratio of two measurements on the same instrument, only the linearity of the detector need be known not the absolute calibration.

The two detector method has the advantage that the readings of the two instruments can be compared electronically and the result displayed directly as $cd.lx^{-1}$.

In the case of dispute between the two methods, the measurand with the lowest uncertainty of measurement should be used.

A4 INSTRUMENTATION

The optical layout of a suitable photometer or optical bench is illustrated in Figure A1. It comprises the following items:

(a) *Light source*

The light source shall be a stable source approximating CIE Standard source A (ISO 11664-2) within a correlated colour temperature accuracy of ±100 K. The exit port of the light source shall be circular and subtend 8 ±3 minutes of arc at the specimen. It shall produce an illuminance that is uniform within a total tolerance of 10% over the entire area of the specimen.

NOTE: To minimize stray light effects, the light source should emit a beam just wide enough to cover the test piece.

(b) *Detector(s)*

The detectors should have a spectral responsivity approximating the CIE 2° Standard Colorimetric Observer (ISO 11664-1). Calibration of the detector(s) shall take into account any departures from this spectral responsivity.

The entrance port of the detector of retroflected light shall be circular and subtend 5 ±2 minutes of arc at the sample.

(c) *Goniometer*

The goniometer shall be capable of holding a specimen mounted as specified in Paragraph J3.2. The goniometer shall be capable of varying both the entrance angle (β_1) and the rotation angle (ε) of the specimen (see Figure A1). The holder is constructed or marked in such a way as to facilitate the taking of the nine equi-spaced illuminance readings required under Paragraphs A5.2(a) or A5.2(b).

The base length of the photometer, i.e. the distance between the test piece and the luminance detector or photoelectric receptor position will be determined by the physical size of available light sources and receptors and the need to arrange these so as to obtain the specified observation angle (α). A minimum base length of 7.5 m is recommended for the single detector method. However, short-base photometry using collimating lenses to obtain equivalent geometry by optical means is not precluded.

(d) *Specimen*

The specimen shall subtend not more than 2° at the light source.

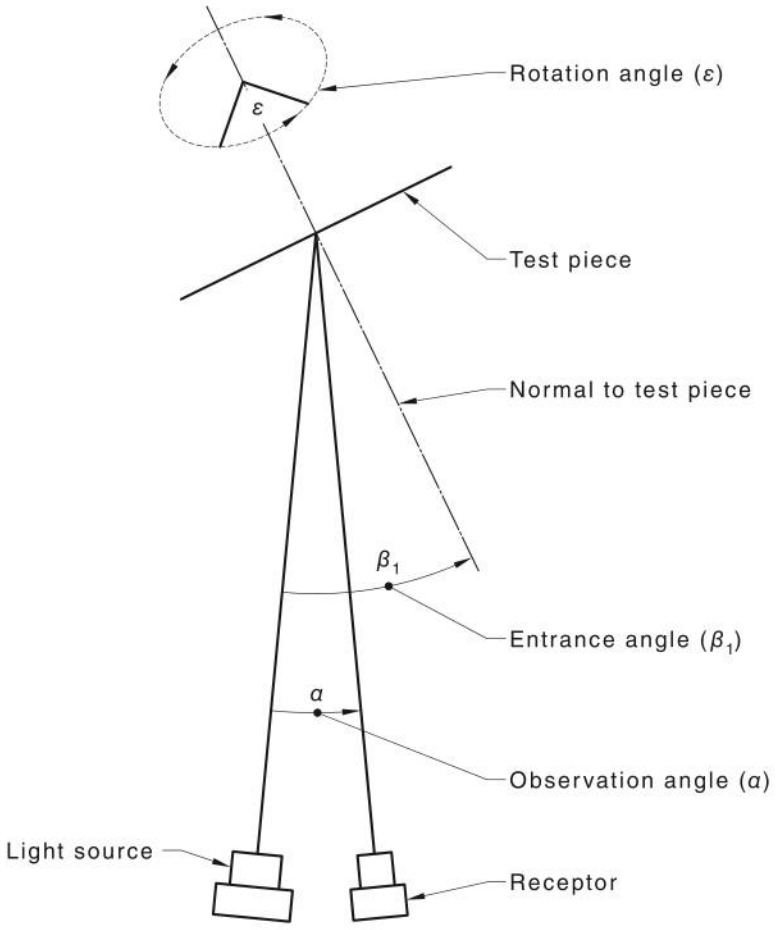


FIGURE A1 OPTICAL LAYOUT OF PHOTOMETER (COPLANAR GEOMETRY)

Measurements shall be carried out with the entrance angle (β_1) and observation angle (α) in the same plane, i.e. with $\beta_2 = 0$ (coplanar geometry) (see Clause 1.4.2.1).

A5 PROCEDURE AND CALCULATION

A5.1 General

The methods used shall result in an uncertainty of measurement not exceeding ±10% of the measured value. The general methods of evaluating the components of uncertainty are set out in ISO/IEC Guide 98-3. For the assessment of uncertainty of measurement in the measurement of retroreflection see CIE 54.2 and Appendix K which specifies how uncertainty of measurement is to be applied in the reporting of results and conformance.

A5.2 Two detector method

The procedure is as follows:

(a) With the illuminance detector located at the sample face point and pointing directly at the light source but with the light source not energized, take an illuminance reading at nine uniformly spaced locations covering the specimen location and size, E_{0i}.

(b) With the illuminance detector located at the sample reference point and pointing directly at the light source but with the light source energized, take illuminance readings at the same 9 points as in Step (a), E_i.

(c) The illuminance at the specimen E_T, is—

$$E_T = \frac{1}{9}\sum_{i=1}^{9}\left(E_i - E_{0i}\right) \quad \ldots \text{A5(1)}$$

where

E_i = the illuminances measured in the plane of the specimen with the illuminating source turned on

E_{0i} = the illuminances measured in the plane of the specimen with the illuminating source turned off

(d) The uniformity of illuminance at the specimen as a percentage, E_U, is—

$$E_U = 100 \times \frac{\left(E_{max} - E_{min}\right)}{2E_T}\% \quad \ldots \text{A5(2)}$$

where

E_{max} = the maximum value of $E_i - E_0$

E_{min} = the minimum value of $E_i - E_0$

E_T = the mean value of E_i [see Equation A5(1)]

E_U shall not exceed 10%.

Locate a detector, appropriately, at the reflected light position and with a field of view sufficient to include the entire test piece from that position.

(e) Identify any manufacturer's markings on the sheet that denote zero rotation angle. The following measurements shall be taken with that mark in the plane of the light source and detector (see Figure A1) and rotated 90°. The two values are averaged.

Where there are no markings, with the observation angle, $\alpha = 0.2°$ and the entrance angles, $\beta_1 = 15°$and $\beta_2 = 0°$, establish the rotation angle at which the luminance or illuminance of the retroreflected light is a minimum. This orientation is designated as rotation angle, $\varepsilon = 0$. The following measurements shall be taken, with the $\varepsilon = 0°$ direction in the plane of the light source and detector (see Figure A1) and when rotated to $\varepsilon = 90°$. The two values are averaged.

(f) Measure the luminance or illuminance when the holder and surrounds are illuminated but no sample is in position, L_0 or E_0'.

NOTE: It may be necessary to measure L_0 or E_0' at each entrance angle and observation angle.

(g) Place the specimen in position. $\varepsilon = 0°$.

(h) Take readings of luminance L_i or illuminance E_i' at the positions listed in Table A1:

TABLE A1
POSITIONS FOR THE MEASUREMENT OF R_A SHEETING $\beta_2 = 0°$

degrees

Observation angle	Entrance angle	
α	β_1	
0.2	4	30
0.5	4	30
1.0	4	30

(i) Measure the area of the specimen, A, in square metres.

(j) For each of the measurements, the luminance $L = L_i - L_{0i}$ or the illuminance $E = E_i' - E_{0i}'$, calculate the luminous intensity, I, using the following equations:

$$I = E\,d^2 \qquad \ldots \text{A5(3)}$$

or

$$I = aL \qquad \ldots \text{A5(4)}$$

where

E = illuminance in lux from the sample

d = distance between the specimen and the detector, in metres

a = Luminance detector measurement area at the sample plane, in m^2

L = Luminance of the sample, in $cd.m^{-2}$

(k) Calculate the specific coefficient of retroreflection, R_A, ($R_I.m^{-2}$) using the following equation:

$$R_A = \frac{I}{E_T A} \qquad \ldots \text{A5(5)}$$

where

I = luminous intensity of the test piece, in candelas, minus stray light reading

E_T= mean illuminance at the test piece, in lux

A = area of the specimen, in square metres

(l) Rotate the specimen so that $\varepsilon = 90°$ and repeat Steps (f) to (k). Calculate the mean R_A from the values for $\varepsilon = 0°$ and 90°.

A5.3 One detector method

The procedure is as follows:

(a) Follow Steps (a) to (d) of the two detector method (see Paragraph A5.2).

(b) Move the detector to the reflected light position and ensure that it has a field of view sufficient to include the entire test piece from that position.

(c) Identify any manufacturer's markings on the sheet that denote zero rotation angle. The following measurements shall be taken with the mark in the plane of the light source and detector (see Figure A1) and rotated 90°. The two values are averaged.

(d) Where there are no markings, with the observation angle, $\alpha = 0.2°$ and the entrance angles, $\beta_1 = 15°$ and $\beta_2 = 0°$, establish the rotation angle at which the illuminance of the retroreflected light is a minimum. This orientation is designated the rotation angle, $\varepsilon = 0$. The following measurements shall be taken, with the $\varepsilon = 0°$ direction in the plane of the light source and detector (see Figure A1) and when rotated to $\varepsilon = 90°$. The two values are averaged.

(e) Measure the illuminance at the reflected light position when the holder and surrounds are illuminated but no sample is in position, E_0.

NOTE: It may be necessary to measure E_0 at each entrance angle and observation angle.

(f) Place the specimen in position $\varepsilon = 0°$.

(g) Take readings of illuminance (E_k) from the sample at the positions listed in Table A1 for sheeting—

$$E = E_k - E_{0k}$$

(h) Measure the area of the specimen A, in square metres.

(i) Calculate the R_A, (R_I/A), value using the following equation:

$$R_A = \frac{E.d^2}{E_T.A} \qquad \ldots \text{A5(6)}$$

where

E = illuminance from the sample, in lux

d = distance between the sample and the detector, in metres

E_T = mean illuminance at the sample, in lux [see A5(1)]

A = measured area of the sample, in square metres

(j) Rotate the specimen so that $\varepsilon = 90°$ and repeat Steps (b) to (i). Calculate the mean R_A for $\varepsilon = 0°$ and 90°.

A6 REPORT

The following shall be reported:

(a) The method used.

(b) The manufacturer's name, the class and colour of the sheeting, and any special identifying information (e.g. conformable grade, retroreflective fabric).

(c) The values of R_A at the nominated geometries with the associated uncertainty of measurement.

(d) Date on which the test was carried out.

(e) The name of the test laboratory or authority responsible for performing the tests.

(f) A reference to this test method, i.e. AS/NZS 1906.1, Appendix A.

APPENDIX B

SELECTION AND USE OF RETROREFLECTIVE SHEETING

(Informative)

B1 GENERAL

All retroreflective sheeting returns light to its source as a cone. The R_A is measured at various observation angles and these correspond to various distances from the centre of the cone (see Figure B1).

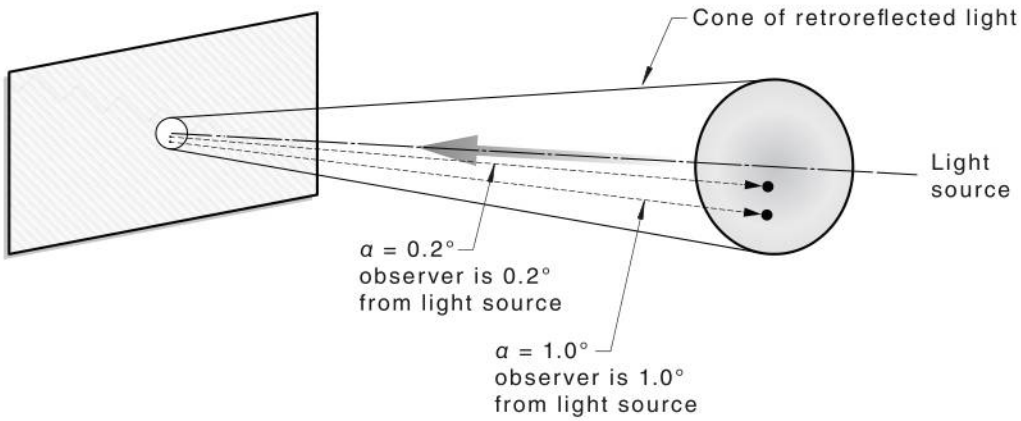


FIGURE B1 CONE OF RETROREFLECTION EXAMPLE

Usually, the R_A reduces as the observer moves further away from the centre of the cone of retro-reflected light, which relates to the observation angle increasing. The efficiency of retroreflective sheeting is determined by the performance capabilities of the reflecting elements within the sheeting, be they glass beads or micro-prisms. It is accepted that micro-prismatic sheetings have a significantly higher level of efficiency compared to glass bead technology sheetings. On the other hand, glass bead sheeting has results that do not depend on orientation.

The cone of retroreflection can be related to the road user scenario through Figures B2 and B3. The observation angle (see Figure B2) relates to the drivers eye position above the headlights (light source). The entrance angle (see Figure B3) then relates to where the road sign is positioned relative to the driver's vehicle, however the entrance angle is continually changing as the driver approaches a sign.

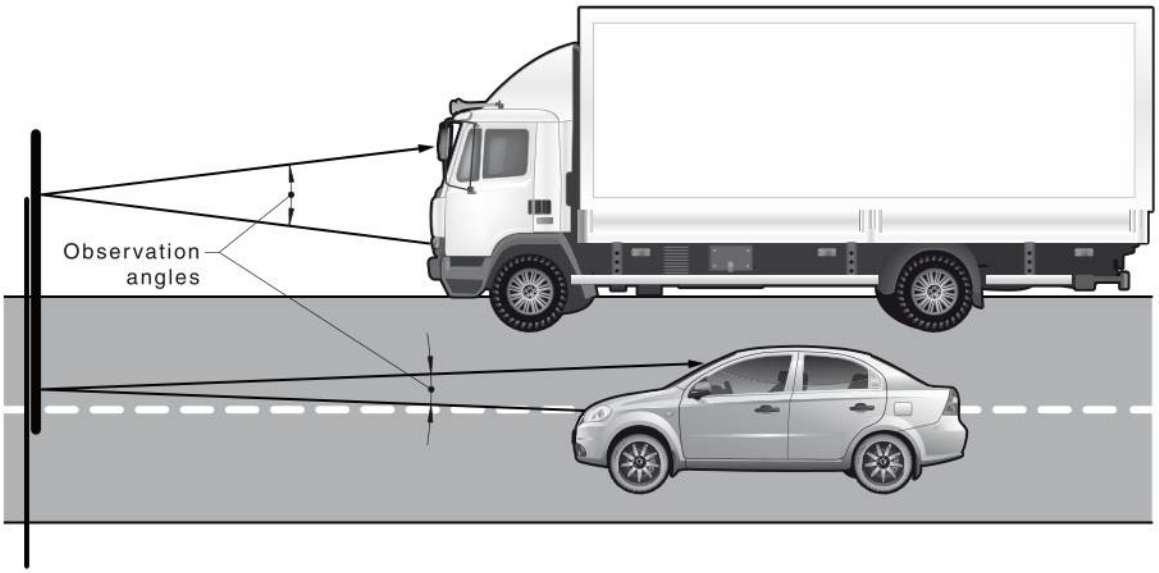


FIGURE B2 EXAMPLES OF DIFFERENT OBSERVATION ANGLES

In Figure B2 the observation angle increases as the driver sits further away from the headlights. In a car the driver is often behind the headlights, but in a truck the driver sits above the headlights.

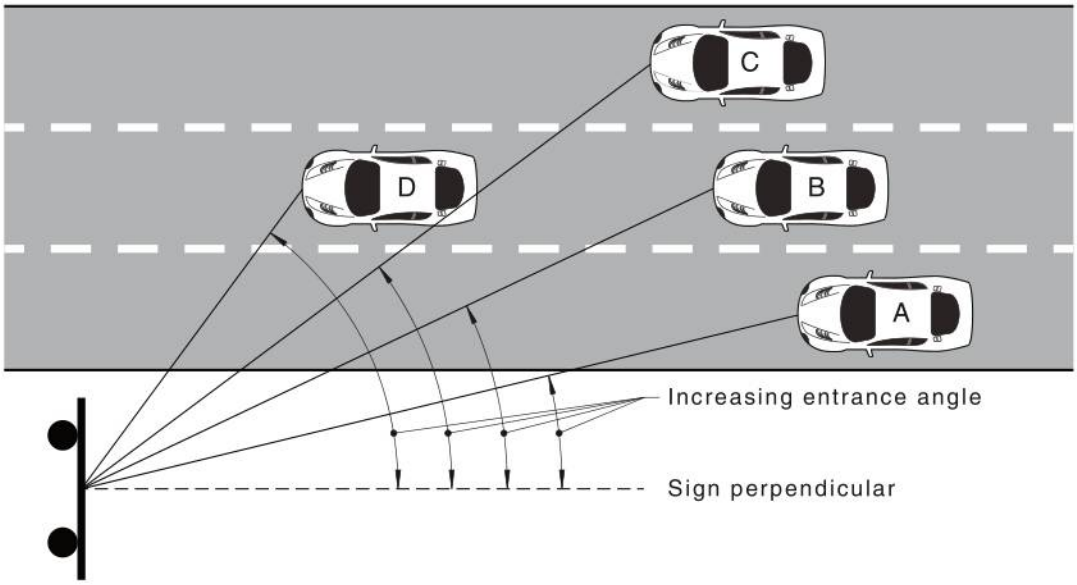


FIGURE B3 EXAMPLES OF DIFFERENT ENTRANCE ANGLES

In Figure B3, the entrance angle increases as the driver moves away from the sign laterally across the road, also as the driver approaches the sign the entrance angle increases.

The luminance of a retroreflective sign (i.e. how bright it appears to a road user) when viewed at night is dependent on the amount of light striking the sign (illuminance), the efficiency with which the light is returned to its source (R_A), and the relative displacement of the drivers' eye from the vehicle headlamps (observation angle).

Retroreflective sheeting that exhibits high efficiency at large observation angles will result in more constant sign brightness (luminance) than sheeting that has relatively large differences in performance across different observation angles. In general, the more uniform the R_A is across the range of observation angles, the more consistently bright (luminous) a traffic sign will appear throughout a vehicle's approach to the sign. Likewise, the appearance of a sign with more constant luminance appears more uniform when viewed from vehicles of different size—family sedan, van or 4WD, light or heavy truck.

Sheetings that have a very high retroreflective (R_A) performance at small observation angles gained at the expense of their wide angle performance will in general, not be suitable for road signs. They are however, considered satisfactory for delineation purposes and are specified in AS/NZS 1906.2 for use in roadside post mounted delineators.

B2 SHEETING CLASSES

Retroreflective sheeting for road traffic control and similar purposes, i.e. sheeting used for road signs and related traffic control devices is specified in this Standard in the classes described in Paragraph B3. The main characteristics which distinguish each of these classes from one another are their retroreflective performance and their outdoor durability.

The relative performances and durability can be gauged to a large extent from the specified performances required of this Standard. However, individual suppliers may be prepared to provide warranties on their sheeting which may provide a more accurate long term life estimate for the purposes of economic evaluation. It is recommended that all these factors are taken into account when making such an evaluation.

B3 SHEETING CHARACTERISTICS

Characteristics of the various classes of sheeting are summarized as follows:

NOTE: Table B1 lists the classes and shows their relationship with superseded classification system.

(a) *Class 100*

Sheeting in this class exhibits a basic level of photometric performance due mainly to the relative inefficiency of the enclosed lens glass bead technology. Typical sheeting durability is accepted as being approximately 7 years although suppliers may offer alternative warranties.

(b) *Class 300*

Sheeting in this class is generally described as having standard performance. They are usually (but not necessarily) an encapsulated lens construction which comprises small high refractive index glass beads encapsulated in an array of small cells protected by a transparent white or coloured plastic sheet over the top.

(c) *Class 400*

Sheeting in this class is generally described as having intermediate performance. They are typically a microprismatic construction, which often means they have a higher efficiency as well as a higher luminance factor, when compared to Class 300, so can give improved colour contrast on the finished sign. Sheetings in this class are often regarded as having a 12 year life although, suppliers may give alternative warranties.

(d) *Class 900*

This sheeting exhibits an intermediate performance level, similar to Class 400 with increased performance at wide entrance and observation angles. It is generally regarded as a 12 to 15 year sheeting but suppliers' warranties may provide a better guide to life expectancies. This sheeting is of microprismatic construction, the description and characteristics of which are given in Paragraph B4.

(e) *Class 1100*

This sheeting exhibits a high performance level, in particular at wider observation angles, and is ideally suited to fully reflectorized signs which are either in disadvantaged positions, substantially off-set to the drivers path or where long viewing distance is preferred or where performance at high angles is required (see Figure B3). This sheeting is of microprismatic construction, the description and characteristics of which are given in Paragraph B4.

A further important characteristic of the Class 1100 is that its combination of long distance and wide observation angle performance means that it is able to perform well at close viewing distances as well.

(f) *Class 1A*

This sheeting is not specified in this Standard. It is of a microprismatic construction with exceptionally high long distance performance especially at small observation angles. It has been specified for use for delineation purposes in AS/NZS 1906.2 but may also be suitable for sign legends in cases where its high level narrow angle performance is appropriate.

(g) *Number plate sheeting—Class NP 090 and NP 090(EMB)*

These are sheetings designed specifically for motor vehicle number plates. They have a performance just lower than that of Class 100 sheeting and may be made as a 'conformable' grade suitable for use on embossed surfaces.

(h) *Work zone sheeting Class (T)*

These are sheetings designed for temporary signs at work zones. They are generally of Class 400 construction but may have a different durability grade commensurate with the life of signs and devices required to be used in particular work zone situations.

TABLE B1

COMPARISON OF CLASSIFICATIONS

New class name	Previous class name
Class 100	Class 2
Class 300	Class 1 Beaded construction
Class 400	Class 1
Class 900	
Class 1100	
Class NP090/NP090 (EMB)	NP and NP (EMB)
Temporary Class T, e.g. Class 400T	Work Zone Class (WZ) e.g. Class 1 (WZ)

NOTE: There is no direct equivalent to the old Classes 1W and 2A.

B4 MICROPRISMATIC RETROREFLECTIVE SHEETING

Microprismatic retroreflective sheetings allow retroreflected light to be aimed and directed far more precisely than is possible with retroreflective sheetings utilizing glass beads. However, because of the ability of the sheeting to be tailored for performance at specific entrance and observation angles relative performances at different combinations of entrance and observation cannot be predicted from sheeting classification.

Sheetings of a certain class from different manufacturers therefore will almost certainly have different performance characteristics.

A microprismatic construction suitable for use on road signs is characterized by the ability to provide desirable luminance (or brightness) at the threshold of sign detection while maintaining a high relative percentage of this luminance throughout the approach to the sign as the observation angle progressively widens.

B5 EFFECTIVE USE OF RETROREFLECTIVE SHEETING ON SIGNS

B5.1 Luminance contrast ratio

When designing a fully reflectorized sign (i.e. one which has a white legend on a coloured background), the ratio of the luminance of the legend to the luminance of the background, when viewed under retroreflective light, should be not less than the values given in Table B2. Maintenance of this luminance contrast ratio will ensure that the loss of legend legibility when compared with legibility under ideal night-time conditions will not exceed 10%.

TABLE B2

REQUIRED MINIMUM LUMINANCE CONTRAST RATIOS BETWEEN WHITE LEGEND AND COLOURED BACKGROUND TO RESTRICT LEGEND LEGIBILITY LOSS TO 10%

Background colour	Luminance ratio (min.)	
	Legend luminance 3.2 cd/m^2 (see Note 1)	Legend luminance 10 cd/m^2 (see Note 2)
Red	8	10
Green	7	7
Blue	6	7

NOTES:

1 Representative of side-mounted traffic signs observed at night under dipped headlight conditions.

2 Representative of side-mounted traffic signs observed at night under high-beam headlight conditions. This column should also be used for urban surroundings where high ambient illumination reduces contrast at night.

B5.2 Partially retroreflective signs

Where a sign is to have only its legend or its background in retroreflective sheeting, there will be adequate luminous contrast between the two at all required viewing angles if the lighter colour is retroreflective.

NOTE: Having a dark retroreflective colour on a light coloured non-retroreflective background, e.g. a blue retroreflective legend on white, can under some viewing conditions cause the legend to disappear altogether.

B6 FURTHER GUIDANCE

Further information about correct sheeting for selection for different road scenarios can be found in the AS 1742 series, such as AS 1742.1, and Austroads, *Guide to Traffic Management*.

APPENDIX C

COLOUR AND LUMINANCE FACTOR TESTS—FLUORESCENT AND NON-FLUORESCENT SHEETING

(Normative)

C1 SCOPE

This Appendix sets out methods of measurement of colour chromaticity coordinates for the following:

(a) Retroreflective sheeting under daylight illumination.

(b) Retroflective sheeting under retroreflected illumination.

(c) Fluorescent sheeting under daylight illumination.

(d) Combined fluorescent/reflective sheeting under both daylight and retroreflective illumination.

The method also includes the measurement of luminance factor for both non-fluorescent and fluorescent sheeting under daylight illumination.

NOTE: Non-retroreflective fluorescent sheetings, see Item (c) above, are not specified in this Standard. They may however, be specified in other Standards that refer back to this Standard for their colour measurement.

C2 PRINCIPLE

For the measurement of colour under daylight illumination two methods are specified as follows:

(a) The single monochromator method which entails illuminating the test piece with a calibrated source closely matching that of the CIE Illuminant D65 (refer to ISO 11664-2) and measuring the colorimetric tristimulus values using a spectrophotometer or a spectroradiometer with a spectral analysing unit. This method is suitable for the absolute measurement of non-fluorescent sheeting and may be used for the measurement of fluorescent sheeting. The luminance factor is determined with the use of a calibrated reflectance tile. A colorimeter may be used as an alternative to this method for the measurement of non-fluorescent sheeting. Calculations of colour and luminance factor are made using CIE 1931 2° standard observer (ISO 11664-1).

(b) The double monochromator method which entails illuminating the test piece with a series of monochromatic beams at intervals no greater than 10 nm. The second monochromator measures the emission spectrum for each one of the series of monochromatic beams illuminating the test piece. The colour tristimulus coordinates can then be calculated for CIE Illuminant D65 (refer to ISO 11664-2). The luminance factor is determined with the use of a calibrated reflectance tile. This method is suitable for use for referee purposes for the measurement of fluorescent sheeting. Calculations of colour and luminance factor are made using CIE 1931 2° standard observer (ISO 11664-1).

The colour of retroreflective sheeting under retroreflected light is measured by illuminating the test piece with a source closely matching that of the CIE Illuminant A (refer to ISO 11664-2) and directly analysing the retroreflected beam with a colour-measuring device. If a monochromator is used to analyse the retroreflected beam then it shall do so at wavelength intervals of no greater than 10 nm. The colour-measuring device shall be at the observation angle $\alpha = 0.33°$ and the entrance angle of the test piece shall be $\beta_1 = 5°$, $\beta_2 = 0°$.

Calculations of colour and luminance factor are made using CIE 1931 2° standard observer (ISO 11664-1).

C3 PROCEDURAL REQUIREMENTS

Sound calibration and verification procedures shall be observed. The precision and bias of the entire measurement system, including verification of total spectral radiance factors and calculation of CIE tristimulus coordinates, shall be determined by periodic measurement of calibrated retroreflective and fluorescent reference material. Calibrated non-fluorescent colour reference materials shall be provided by the instrument supplier. The calibration of fluorescent colour reference materials shall be traceable to a material standard. The method shall be in accordance with CIE 54.2.

C4 INSTRUMENTATION

Instrumentation shall comprise the following:

(a) Spectroradiometer or spectrophotometer with sufficient wavelength range and sensitivity to measure both the incident and reflected spectral irradiance and radiance encountered in the measurement of test pieces.

(b) Monochromators as follows:

(i) Wavelength range 300 to 780 nm.

(ii) Bandpass—10 nm maximum.

(iii) Interval—10 nm (set table within 0.2 nm).

(c) Light source as follows:

(i) *For simulated daylight measurement*:

The light source shall be a source that closely matches the CIE Illuminant D65. If the source is to be used to measure the colour and luminance factor of fluorescent sheeting by the single monochromator method, it shall conform to the following:

(A) For test pieces having visible-activated fluorescence, it shall have a visible source conformance factor (SCF) of less than 10 calculated as follows:

$$\text{Visible SCF} = [(1/n)\ \Sigma\ (S_{D65} - S_{inst})^2]^{0.5} \quad \ldots \text{C4(1)}$$

where

n = the number of sample points

S_{D65} = the relative spectral power distribution of CIE Illuminant D65 normalized to 100 at 560 nm

S_{inst} = the spectral power distribution of the radiation falling on the test piece normalized to 100 at 560 nm

The sum shall be taken over the spectral range 380 nm to 780 nm at 20 nm intervals.

(B) For test pieces having ultra-violet-activated fluorescence, the light source shall have a UV source conformance factor (SCF) of less than 15 calculated as follows:

$$\text{UV SCF} = [(1/n)\ \Sigma\ (S_{D65} - S_{inst})^2]^{0.5} \quad \ldots \text{C4(2)}$$

where

n = the number of sample points

S_{D65} = the relative spectral power distribution of CIE Illuminant D65 normalized to 100 at 560 nm

S_{inst} = the spectral power distribution of the radiation falling on the test piece normalized to 100 at 560 nm

The sum shall be taken over the spectral range 300 to 380 nm at 20 nm intervals.

If a colorimeter is used (i.e. for non-fluorescent sheeting only), it shall be calibrated against a standard closely approximating the colour of the sample, and care taken to ensure that the light source meets the requirements for CIE Illuminant D65 in Item (A).

(ii) *For retroreflected light measurement*:

The light source shall closely match the CIE Standard Illuminant A. It shall have 0.5% maximum change in output over the period of the measurements. It shall have a spatial uniformity of 2% variation maximum over the test pieces. It shall have an effective spectral distribution of 380 to 780 mm.

(d) The minimum area at the sample shall be no less than 490 mm^2.

(e) The instrument geometry shall be (45°×:0° or 0°:45°×) or (45°a:0° or 0°:45°a) as defined in CIE 15:2004.

C5 PROCEDURE

The procedure shall be as follow:

(a) Mount adhesive backed sheeting samples as specified in Appendix J.

Mount samples of sheeting not intended to be mounted on a rigid surface, in a single layer, including any in-service backing or lining used in their construction, on a rigid, non-staining, matt surface of less than 5% diffuse reflectance. The sample shall be flat but not stretched.

(b) Except as specified in Item (c), using whichever of the methods set out in Paragraph C2 is appropriate to the situation, measure the colorimetric tristimulus values of the sample in at least three areas and determine the mean of each to give the total luminance factor (β_T) and the chromaticity coordinates (x, y).

(c) For cellular or other sheeting with a discontinuous surface, when measured with an instrument with a small field of view, so that the size of the cell wall or discontinuity is appreciable compared to the field of view, obtain the mean of a minimum of six readings of both colour coordinates and luminance factor taken at different, randomly selected points over the surface, to ensure that the measurements are representative of the surface as a whole.

C6 REPORT

The following shall be reported:

(a) The manufacturer's name, class and colour of the sheeting.

(b) The test method, instrument geometry and light source used.

(c) The chromaticity coordinates and luminance factor values.

(d) The name of the test laboratory or authority responsible for performing the tests.

(e) A reference to this test method, i.e. AS/NZS 1906.1, Appendix C.

APPENDIX D

CIE CHROMATICITY LIMITS (COLOUR SPACES) FOR COLOUR DESIGNATION

(Informative)

This Appendix shows the following chromaticity limits for colour designations as specified in Clause 2.2 plotted on the CIE colour chart for the following sets of chromaticity coordinates:

(a) Non-fluorescent colours—Daylight illumination (see Figure D1).

(b) Fluorescent colours—Daylight illumination (see Figure D2).

(c) Non-fluorescent colours—Retroreflected illumination (see Figure D3).

(d) Fluorescent colours—Retroreflected illumination (see Figure D4).

(e) Class NP090 and NP090 (EMB) sheeting—Daylight illumination (see Figure D5).

(f) Class NP090 and NP090 (EMB) sheeting—Retroreflected illumination (see Figure D6).

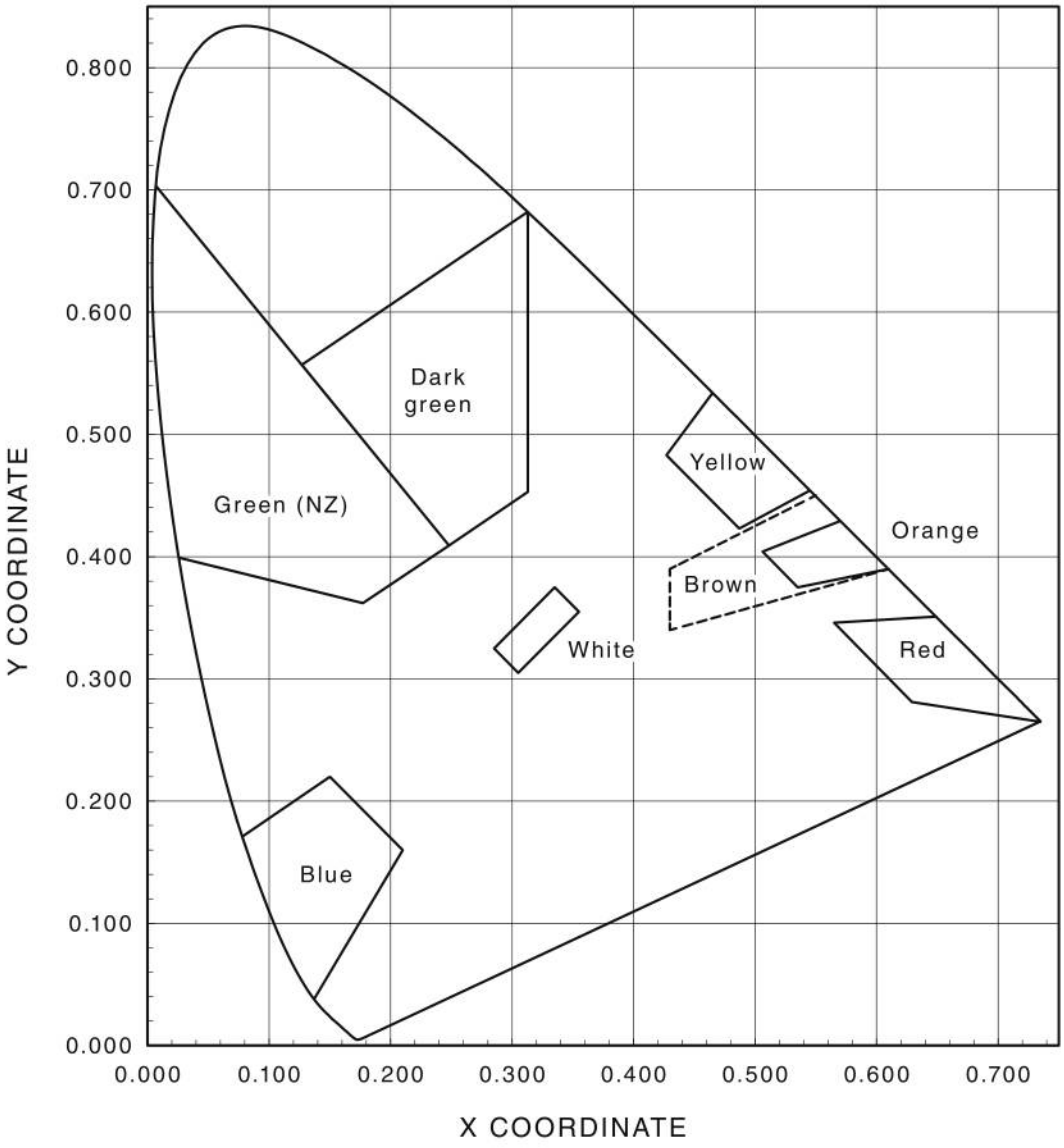


FIGURE D1 NON-FLUORESCENT COLOURS DAYLIGHT ILLUMINATION
(SEE TABLE 2.6)

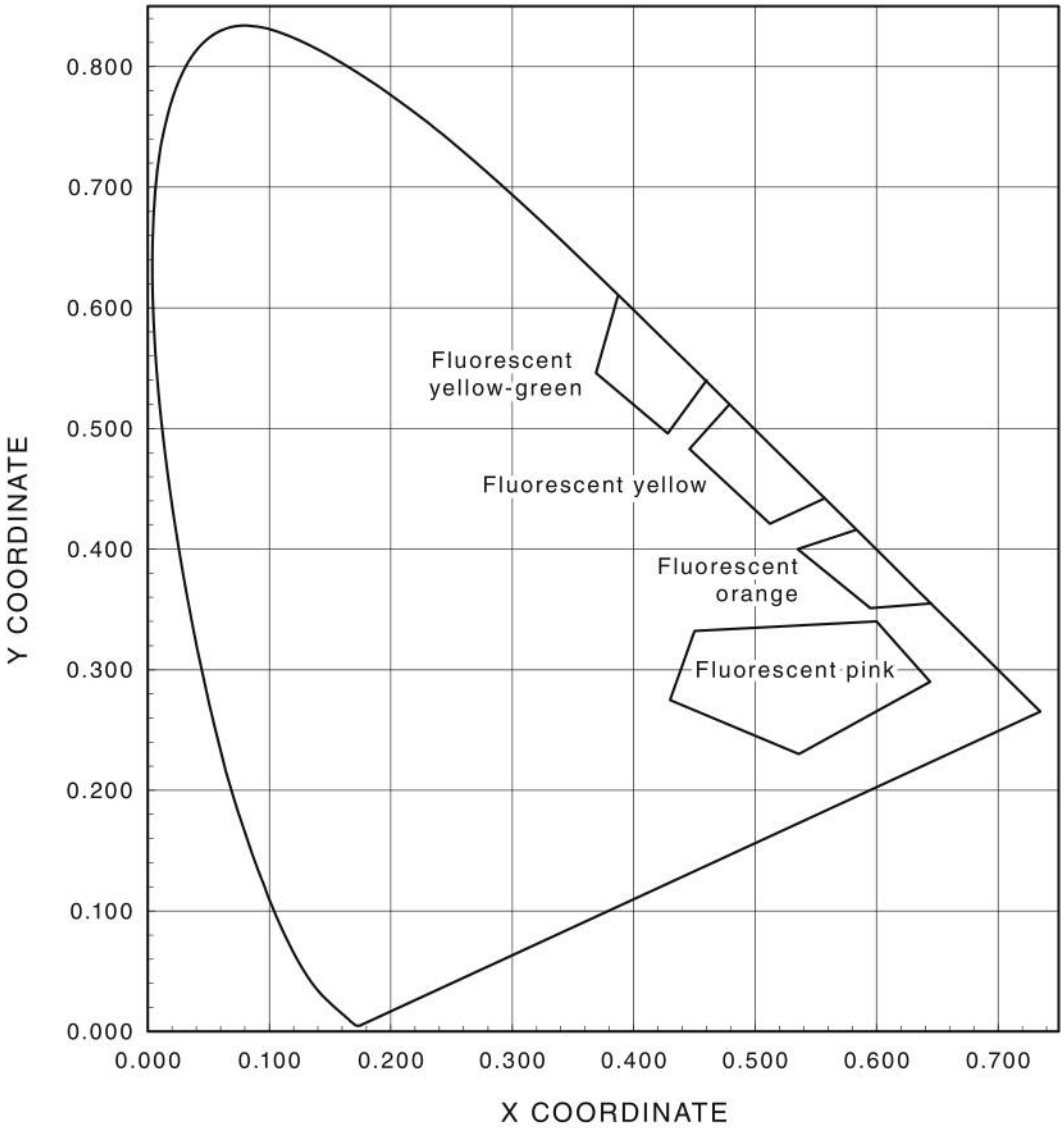


FIGURE D2 FLUORESCENT COLOURS DAYLIGHT ILLUMINATION
(SEE TABLE 2.6)

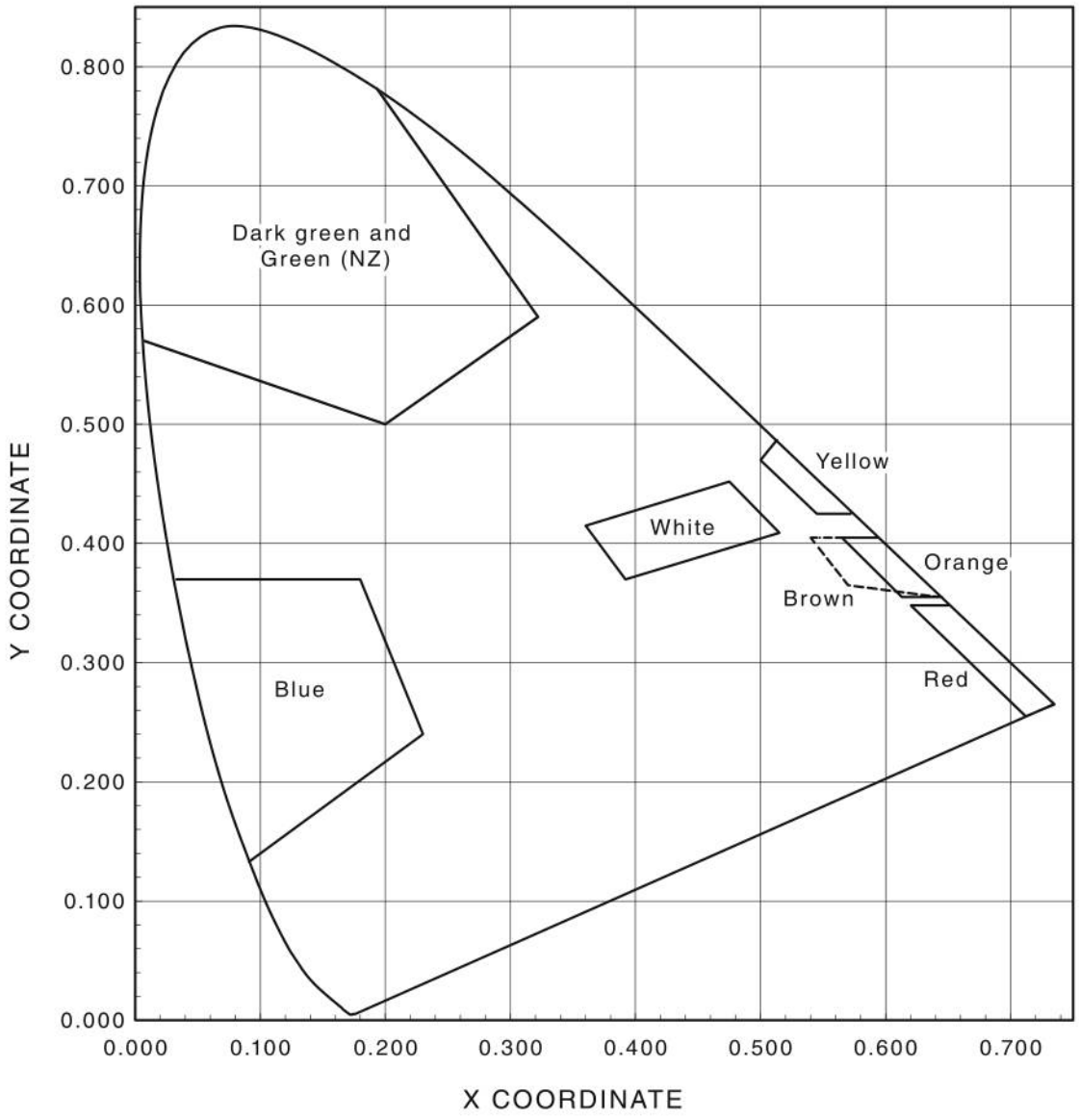


FIGURE D3 NON-FLUORESCENT COLOURS RETROREFLECTED ILLUMINATION
(SEE TABLE 2.7)

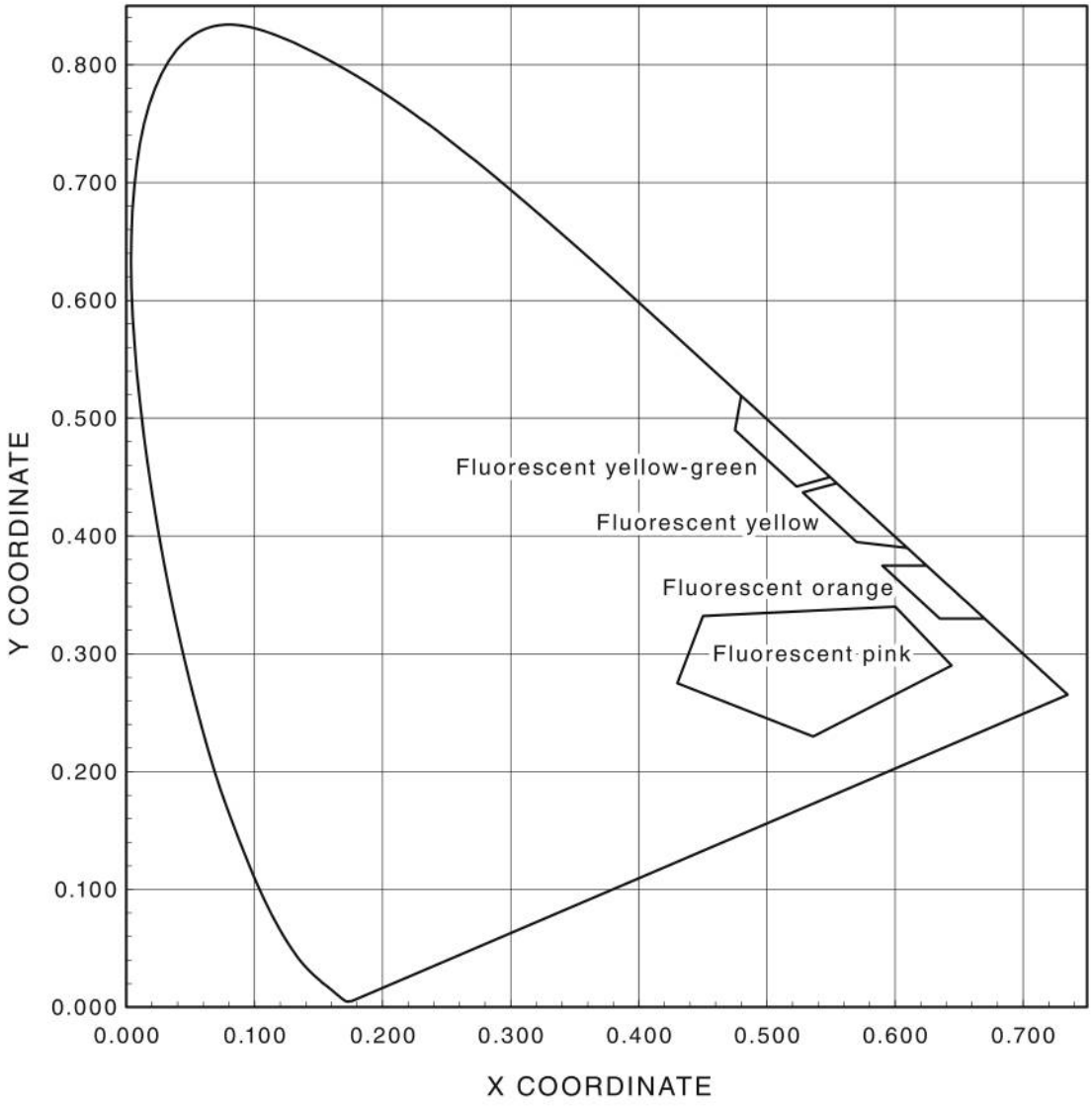


FIGURE D4 FLUORESCENT COLOURS RETROREFLECTED ILLUMINATION
(SEE TABLE 2.7)

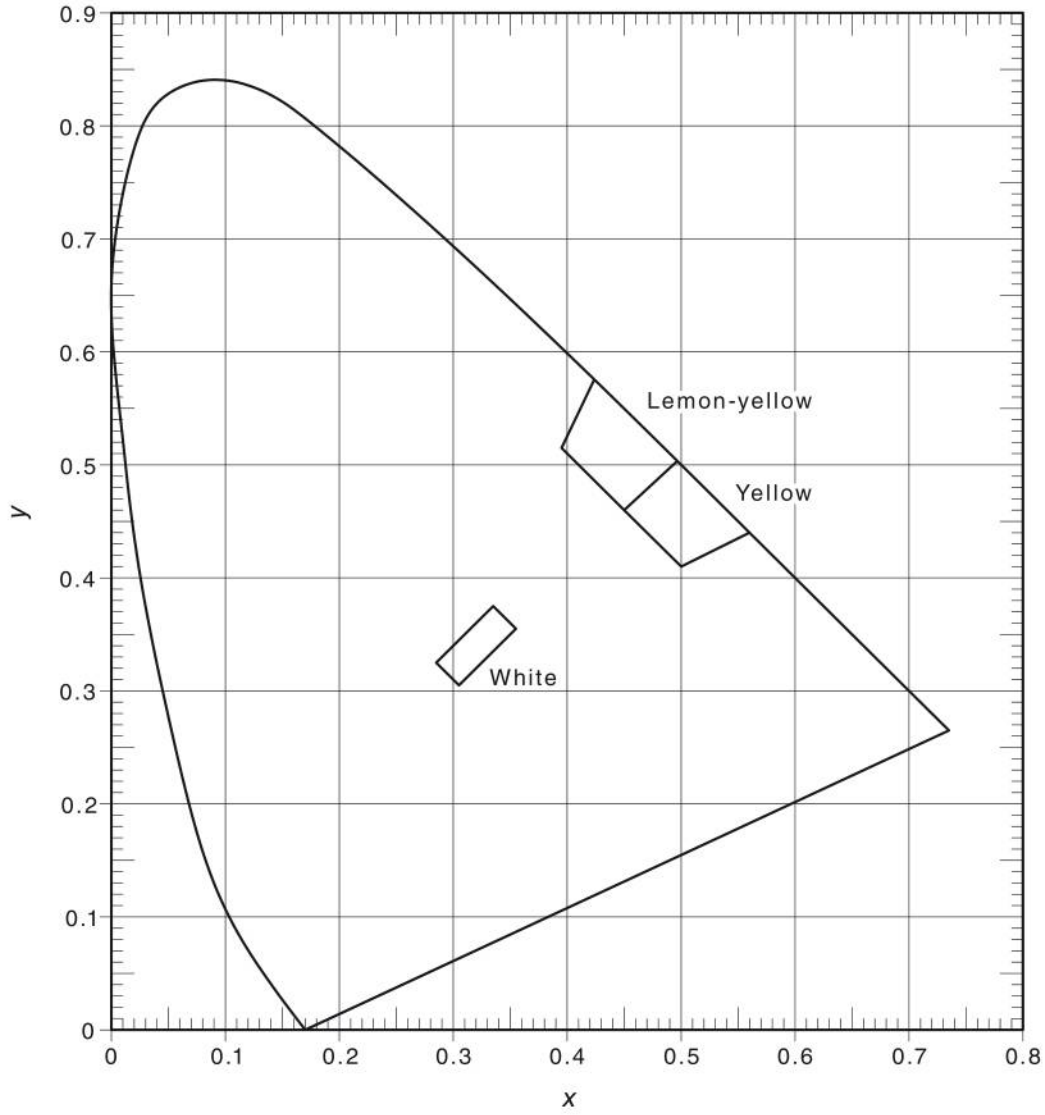


FIGURE D5 CLASS NP090 AND NP090 (EMB) SHEETING
DAYLIGHT ILLUMINATION (SEE TABLE 3.2)

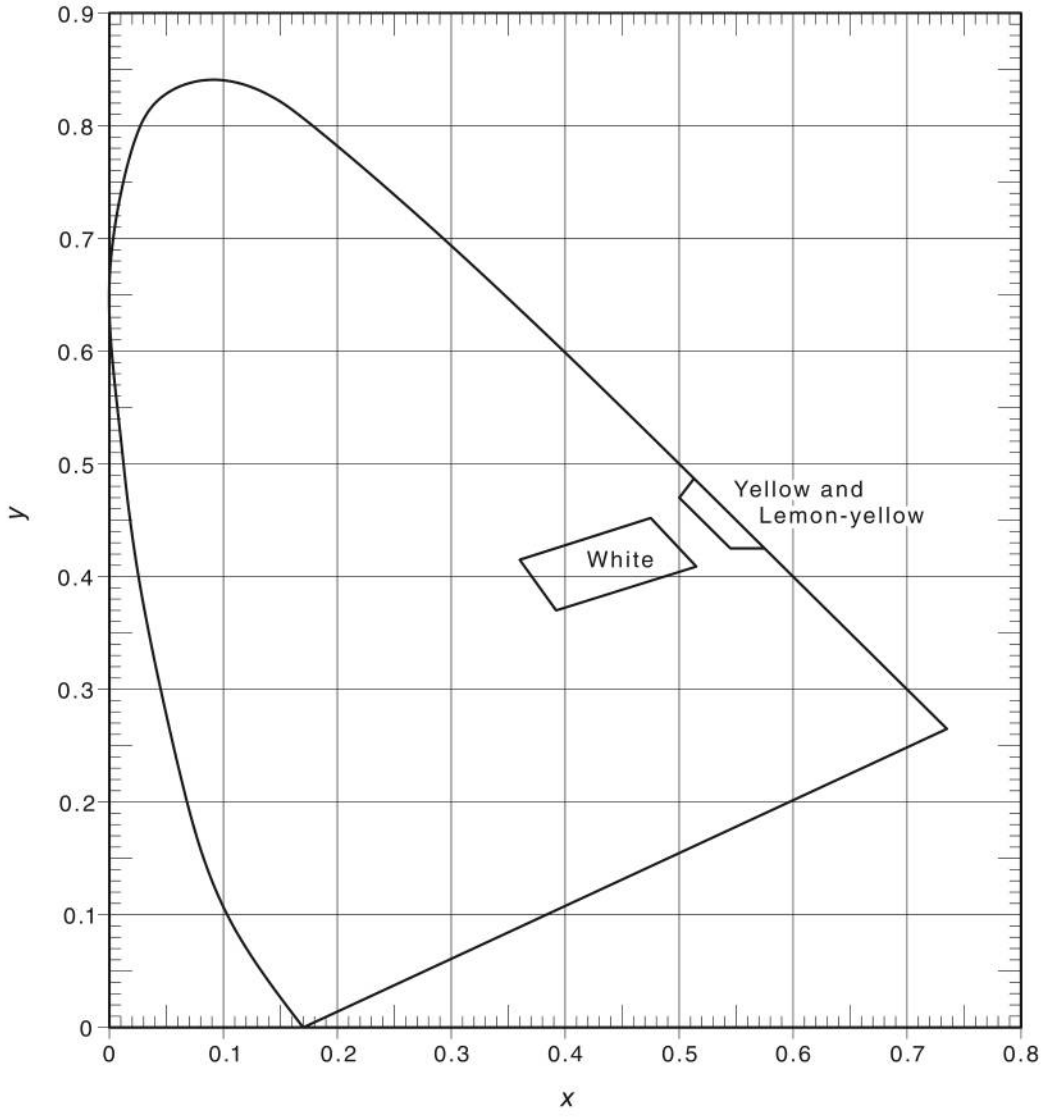


FIGURE D6 CLASS NP090 AND NP090 (EMB) SHEETING
RETROREFLECTED ILLUMINATION (SEE TABLE 3.3)

APPENDIX E

PHOTOMETRIC PERFORMANCE TEST UNDER SIMULATED RAIN CONDITIONS

(Normative)

E1 SCOPE

This Appendix sets out the procedures required to measure photometric performance of a retroreflective sheeting under simulated rainfall conditions.

E2 PRINCIPLE

A test specimen is mounted in the vertical plane and subjected to a continuous spray of water droplets simulating rainfall, during which its R_A value is measured.

E3 APPARATUS

The following apparatus is required:

(a) A suitable apparatus for mounting the specimen in the spray of water is illustrated in Figure E1. The specimen (A) is supported on the vertical specimen holder (B) above the catch trough (C) and drain (D). The specimen holder is rigidly attached to the goniometer table (not shown), but is held away from it so that part of the spray goes behind the sample. The spray nozzle (E) is rigidly supported in a position which is fixed relative to the specimen and is supplied with clean tap water at constant but adjustable pressure through a flexible joint (F) or hose.

The nozzle is 1 m above the specimen and is so angled that where the spray strikes the specimen the axis of the cone of the spray is set an angle θ of between 5° and 10° to the vertical. The specimen, specimen holder and spray nozzle are enclosed in a cover (G) designed to protect the optical apparatus from water. Preferably, the cover is made of or incorporates large areas of rigid transparent plastic material for visibility and has at least one removable panel or door for access. A square aperture (H), or side 150 mm, is provided for the light path and a gutter (J) protects this aperture from falling water. The region of the cover near to this aperture is painted matt black to reduce stray reflections. The nozzle consists of an orifice of diameter 1.19 mm with an appropriately designed feed pipe producing a substantially uniform solid cone spray.

NOTE: Calibration of the rain gauge measuring flask (in millimetres) should take account of the ratio of the plan area of the receiving funnel to the cross sectional area of the flask.

(b) A photometer as shown in Figure E2 with orthogonal geometry.

E4 TEST SPECIMENS

Prior to making up test panels, sheetings shall be tested in the dry state to determine if any are orientation sensitive. Those identified as such shall be tested at orientation angles $\varepsilon = 0°$ and $\varepsilon = 90°$ and the results averaged. The rotation angle $\varepsilon = 0°$ shall be determined as specified in Paragraph A5.2(e). Test panels shall then be made up in accordance with Appendix J so that R_A testing is done at these rotation angles. Sheetings that are not orientation sensitive shall be tested at any one rotation angle.

E5 PROCEDURE

The test procedure is as follows:

(a) Calibrate the apparatus for measuring the R_A value with the wet testing apparatus in place and determine a correction for stray light under wet conditions.

(b) Mount a flat square specimen of the sheeting of side 100 ±5 mm in a vertical plane on the vertical specimen holder so that the holder does not protrude beyond the edge of the specimen at any point. If the sheeting is orientation sensitive when dry, mount it so that measurements can be made at both rotation angles $\varepsilon = 0°$ and $\varepsilon = 90°$.

(c) Adjust the nozzle and water supply to subject the specimen to a spray of clean tap water so that the whole face of the specimen is within the envelope of the spray and the axis of the spray is at angle θ to the face of the specimen and the water striking it at an angle between 5° and 10°, and the flow rate striking the specimen is equivalent to a rainfall, in millimetres per hour, of 285 ±15 $mm.h^{-1}$ as measured in Step (d). The spray shall be maintained in a steady state for at least 2 min before and throughout the measurement.

NOTES:

1 Flow rate should be established by means of one or more timed trials prior to inserting the specimens into the specimen holder.

2 The specified flow rate is an approximation.

(d) The simulated rainfall rate striking the specimen shall be measured in accordance with ANSI/ISEA 107.

NOTE: Flow rate should be established by means of one or more timed trials prior to inserting the specimens into the specimen holder.

(e) Determine the R_A value at $\alpha = 0.2°$, $\beta_1 = 0°$ and $\beta_2 = 4°$ as specified in Figure E2. For orientation sensitive material the R_A is the average determinations at rotation angles $\varepsilon = 0°$ and $\varepsilon = 90°$.

E6 REPORT

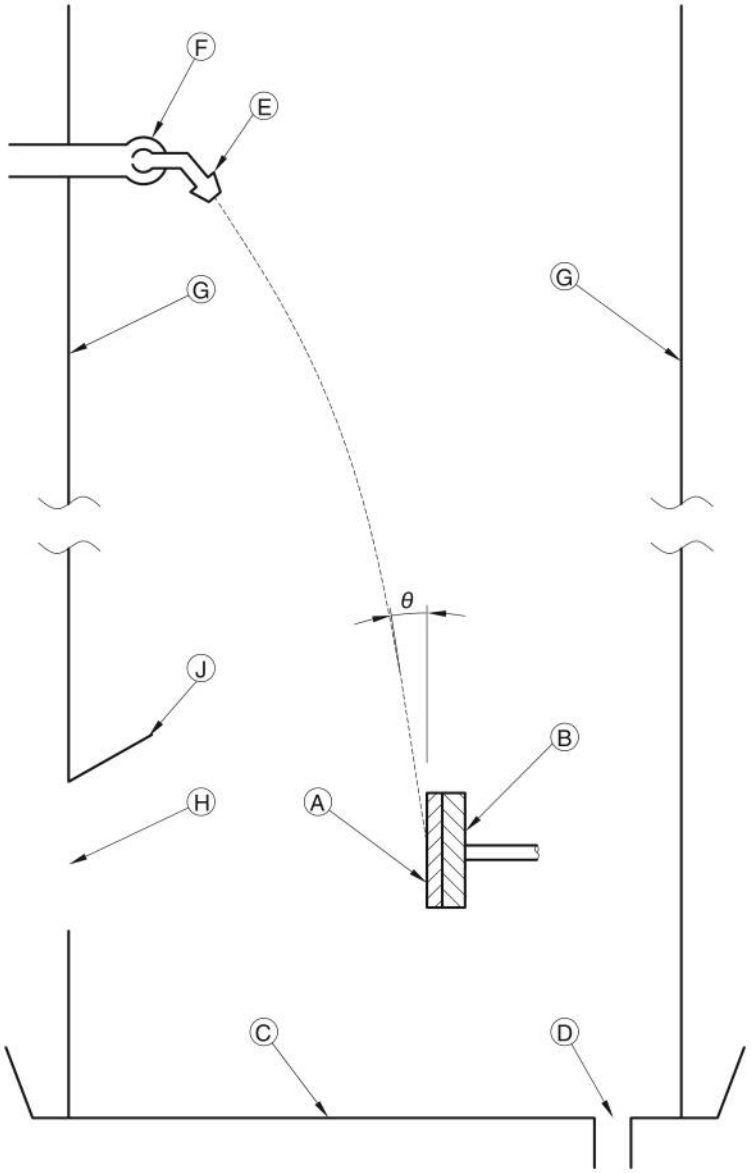
The following shall be reported:

(a) The manufacturer's name, the class and colour of the sheeting, and any special identifying information.

(b) The R_A value at $\alpha = 0.2°$ and $\beta_2 = 4°$ measured during the spray application.

(c) The name of the test laboratory or authority responsible for performing the tests.

(d) A reference to this test method, i.e. AS/NZS 1906.1, Appendix E.



LEGEND:

A	specimen
B	vertical specimen holder
C	catch trough
D	drain
E	spray nozzle
F	flexible joint
G	cover
H	square aperture
J	gutter

SYMBOLS DESCRIBED IN TEXT

NOTE: The angle θ shall be between 5° and 10°.

FIGURE E1 APPARATUS FOR RAINFALL TEST

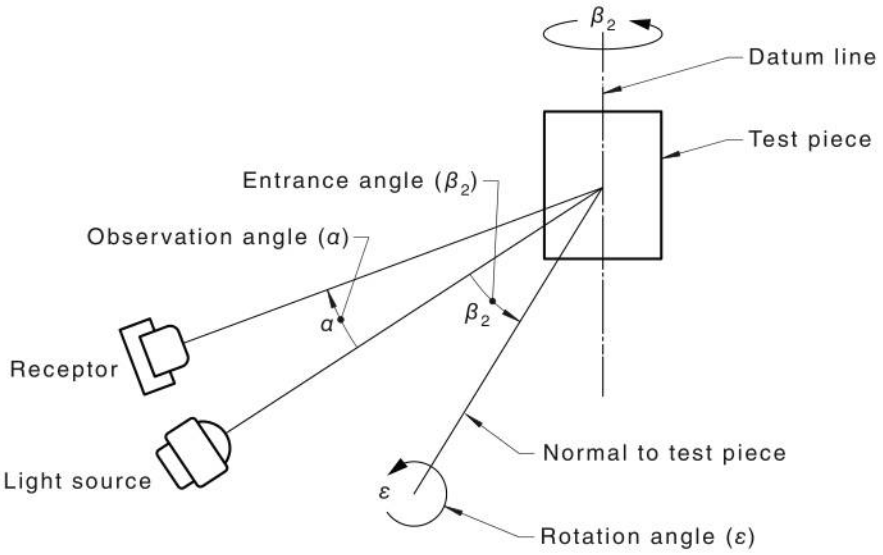


FIGURE E2 OPTICAL LAYOUT OF PHOTOMETER (ORTHOGONAL GEOMETRY)

APPENDIX F

PHYSICAL PROPERTIES TEST

(Normative)

F1 SCOPE

This Appendix sets out tests for determining the following physical properties of retroreflective sheeting:

(a) Tensile strength and elongation test (see Paragraph F2).

(b) Impact test (see Paragraph F3).

(c) Scratch resistance test (see Paragraph F4).

(d) Scrub abrasion test (see Paragraph F5).

F2 TENSILE STRENGTH AND ELONGATION TEST

F2.1 Apparatus

The machine used for this test shall be a tensile testing machine.

Prepare test pieces by cutting nine (9) samples, each 250 mm long and 25 mm wide as follows and condition as specified in Paragraph J3:

(a) Three pieces parallel to the longitudinal axis of the roll.

(b) Three pieces normal to the longitudinal axis of the roll.

(c) Three pieces at 45° to the longitudinal axis of the roll.

NOTE: Care should be exercised in cutting samples as poor cutting may influence test results adversely.

F2.2 Procedure

The procedure shall be as follows:

(a) After removing the liner, place each test piece in turn in the testing machine with a length of 200 mm between the grips.

(b) Set the rate of travel to 500 mm/min. Jaw breaks shall be excluded.

(c) All samples shall be tested and the results reported. Conformance is determined against the minimum value obtained.

(d) Determine the elongation by measuring the increase in length of the section of sheeting between the grips at break point, and expressing this as a percentage of the original length between the grips.

(e) For sheeting other than Class NP090 (EMB) record the greatest elongation observed for any of the successful tests.

(f) For Class NP090 (EMB) sheeting record the least elongation observed for any of the tests.

F3 IMPACT TEST

F3.1 Apparatus

The apparatus required for this test comprises a steel rod plunger having a mass of 1000 ±50 g and a hemispherical tip of 15 ±1 mm diameter which can drop from a height of 100 ±5 mm through a guide tube with maximum clearance of 2 mm on to the face of the supported test panel. The support shall consist of an annular die with an internal diameter of 17 ±1 mm, centrally located under the plunger.

F3.2 Procedure

The procedure shall be as follows:

(a) Prepare a test piece measuring at least 200 mm long and at least 60 mm wide by mounting and conditioning as specified in Paragraphs J3.1 and J2, respectively.

(b) Check that the guide is vertical and that the plunger falls freely. Ensure the tip of the plunger and the rim of the die are free of burrs or any other defect likely to damage the sheeting under test.

(c) Place the test panel on the die to allow for an impact on the rear of the test panel. The panel shall be located so that the impact is not less than 25 mm from any edge.

(d) Raise the plunger to the prescribed height and allow it to fall. Ensure that the guide tube height is set correctly and accurately record the true dropping height.

(e) Repeat Steps (c) and (d) four times with each impact point being at least 40 mm away from its neighbour and at least 25 mm away from any edge.

(f) Examine the surface of the test sheeting under 10× magnification at each impact zone, noting any cracking, crazing or lifting of the sheeting from the substrate or inter-layer delamination. Note the number of test zones showing the presence of such defects. Any cracking crazing, lifting or interlayer delamination in more than two impacted zones the sample shall constitute a failure of this test.

(g) Check the adhesion of the test sheeting in the impact zone as follows:

  (i) Using a sharp and pointed knife, and commencing at the rim of the impact, attempt to remove the retroreflective sheeting from the substrate with a gentle prising action.

  (ii) Report the ease of removal of the sheeting compared to its adhesion in a non-impacted area. If the sheeting in the test zone is more easily removed than that in the non-impacted area, the sheeting is deemed to have lost its integrity. If the sheeting is deemed to have lost its integrity in more than two impacted zones the sample shall have failed this test.

F4 SCRATCH RESISTANCE TEST—SHEETING OTHER THAN CLASS NP090 AND CLASS NP090 (EMB)

The scratch resistance test shall be carried out as follows:

(a) Mount and condition a test piece at least 100 mm long by at least 50 mm wide as specified in Paragraphs J3.1 and J2, respectively.

(b) Subject the test piece to the scratch resistance test described in AS/NZS 1580.403.1 ensuring that repeat scratches do not interfere with previous scratches.

(c) Record the maximum load in grams, that the film will withstand without ‘scratch through’.

NOTE: The visual observation may be satisfactorily confirmed by electrical indications (e.g. the filament of a lamp becoming incandescent), depending on the electrical conductivity of the various structures of the retroreflective sheeting.

F5 SCRUB ABRASION TEST—CLASS NP090 AND NP090 (EMB) SHEETING ONLY

F5.1 Apparatus

The following apparatus shall be used:

(a) Straight line washability machine as specified in ASTM D2486-06* with a cycle time of 37 ±1 cycles per minute and a stroke length of 250 ±20 mm.

(b) Nylon bristle brush and brush holder as illustrated in Figure F1 with a total weight in use of 454 ±10 g (including the machine test head) The brush shall comprise an 88 ±0.5 mm × 37 ±0.5 mm alloy block holding bristles with a contact area of 88 ±0.5 mm × 29 ±0.5 mm.

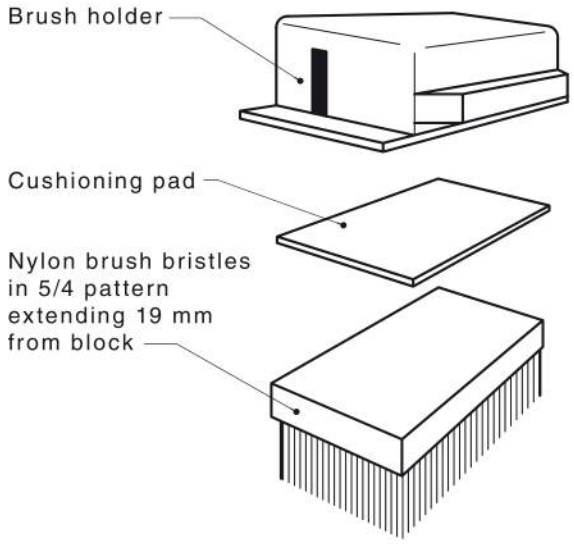


FIGURE F1 NYLON BRISTLE BRUSH AND HOLDER

F5.2 Procedure

The procedure shall be as follows:

(a) Place one finished† vehicle number plate measuring at least 300 mm × 100 mm in the sample tray of the tester under the nylon bristle brush.

(b) Add 10 mL of a neutral (pH 7.0 ±0.5) non-ionic detergent and approximately 100 mL of water to the sample tray so that the number plate is wet.

(c) Run the tester for 3000 cycles.

(d) During the test ensure that the number plate remains wet. Add more detergent/water solution if necessary.

(e) At the completion of the test remove the number plate, wash it with water and dry it with a soft cloth. Evaluate the abrasion in accordance with Paragraph F5.3 and record it.

---

* A suitable machine is the BYK-Gardner Abrasion Tester AG-8101 from BYK Gardner USA.

† A fully finished plate without the final printed overlay

F5.3 Evaluation

The abrasion shall be evaluated as follows:

(a) *Excellent*—no perceptible change in either the reflective sheeting or in the film or process colour coating.

(b) *Good*—slight scuffing of the reflective sheeting or in the film or process colour coating but the sheeting is not visible through the film or process colour coating.

(c) *Poor*—significant abrasion of either the reflective sheeting or in the film or process colour coating, or the film or process colour coating shows evidence of cracking, crazing, peeling or lifting from the base sheeting.

F6 REPORT

The following shall be reported:

(a) The manufacturer's name, the class and colour of the sheeting, and any special identifying information.

(b) The breaking strength and elongation as determined under Paragraph F2.

(c) Any cracking, crazing or lifting from the test panel of the sheeting as a result of the test in Paragraph F3.2.

(d) The maximum load the sheeting will withstand before scratch through in Paragraph F4.

(e) The evaluation of the sample after completion of the test in Paragraph F5, excellent, good or poor.

(f) The name of the test laboratory or authority responsible for performing the tests.

(g) A reference to this test method, i.e. AS/NZS 1906.1, Appendix F.

APPENDIX G

SOLVENT RESISTANCE TEST

(Normative)

G1 SCOPE

This Appendix sets out test procedures for determining the resistance of sheeting to attack from solvents commonly available in the community.

G2 SOLVENTS

The following solvents shall be used:

(a) Petrol (unleaded 91 octane).

(b) Mineral turpentine.

(c) Diesel fuel.

(d) Methylated spirit (undiluted).

G3 APPARATUS

The test shall comprise a straight line washability machine as specified in Paragraph F5.1 with the scrubbing brush removed and replaced with a transversely mounted impervious block with a contact area of 80 ±0.5 mm × 29 ±0.5 mm. This block is covered with unbleached cotton cloth of weight 130 g/m^2–150 g/m^2 folded to create a pad 5 ±1 mm thick (see Figure G1).

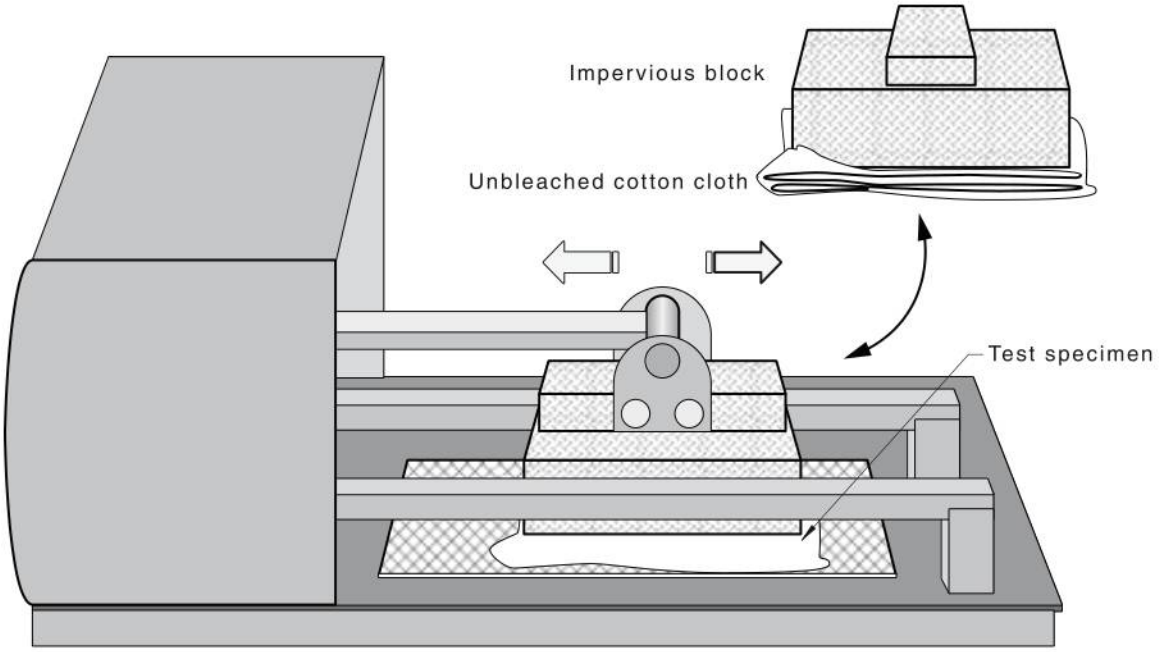


FIGURE G1 EXAMPLE OF A WASHABILITY MACHINE MODIFIED FOR SOLVENT RESISTANCE TEST

G4 PROCEDURE

The procedure shall be as follows:

(a) Prepare and condition 4 (four) test pieces, one for each solvent, each 100 mm × 100 mm, as described in Paragraphs J2 and J3 respectively.

(b) For each of the solvents apply a sufficient amount to saturate a fresh pad of the cotton staining cloth ensuring that the solvent is contained in the cloth and is not dripping.

(c) Place the sample in the tray of the machine under the cloth pad.

(d) Run the tester for 40 cycles.

(e) At the completion of the test allow the panel to air dry.

(f) Check for any colour transfer to the cloth pad, or any other deterioration such as softening or dissolving of the surface or total removal of the surface material.

(g) For white sheeting measure the R_A values at $\alpha = 0.2°$, and $\beta_1 = 4°$ and $\beta_2 = 0$ for each of these test pieces specified in Appendix A.

(h) For all other coloured sheeting measure the luminance factor and daylight chromaticity coordinates in accordance with Appendix C.

G5 REPORT

The following shall be reported:

(a) The manufacturer's name, class and colour of the sheeting and the solvent used.

(b) Any evidence of colour transfer on the unbleached cotton cloth.

(c) Any evidence of deterioration such as softening or dissolving of the surface or the total removal of the surface material.

(d) The calculated R_A values at $\alpha = 0.2°$, $\beta_1 = 4°$, and $\beta_2 = 0$ as a result of the solvent resistance test, for white sheeting only.

(e) For all other coloured sheeting, the measured luminance factor and daylight chromaticity coordinates.

(f) The name of the test laboratory or authority responsible for performing the tests.

(g) A reference of this test method, i.e. AS/NZS 1906.1, Appendix G.

APPENDIX H

ADHESIVE PROPERTIES TESTS

(Normative)

H1 SCOPE

This Appendix sets out a method of conducting dry adhesion tests.

H2 PRINCIPLE

For the dry adhesion tests conditioned samples of sheeting are attached to a substrate and then peeled off at right angles to the substrate, noting the force required to peel the sheeting or the force at which it breaks prior to peeling.

H3 APPARATUS

The apparatus for the adhesion tests shall comprise a device capable of applying a tensile force in the range 2 N to 20 N with a resolution of 0.1 N and an uncertainty of ±0.2 N or better at an angle of 90° ±10° from the plane of the supported test panel. The rate of strain shall be capable of being assessed to ±1 mm/min at 10 mm/min. The clamping mechanism shall be designed to firmly hold the sample and evenly distribute the stress over the whole width of the sample.

H4 DRY ADHESION TEST

The dry adhesion test shall be carried out as follows:

(a) Prepare five test panels as specified in Paragraph J3.1, each comprising a test piece 250 mm long by 25 mm attached to the panel with a minimum of 25 mm length remaining free at one end with liner remaining on the last 15 mm to 20 mm to form an edge to attach the clamping device. During removal of the liner, record whether the liner breaks or tears, or removes any adhesive from the sample. Discard any samples of laminated sheeting where any laminations have been fractured during the cutting or application process.

(b) Condition the sample as specified in Paragraph J2.

(c) Immediately after conditioning, fit the first test panel to the testing device and gradually increase the tensile force until the sheeting peels from the panel at a rate of 10 mm ±2 mm per minute. Continue the test until the tensile force required to peel the sample at the above rate remains constant ±0.2 N over a period of at least 1 minute. Record the mean stress over this period to the nearest 0.5 N/25 mm width as the adhesive limit. If the stress does not stabilize, report the adhesive limit as the minimum force recorded. If the sample breaks before peeling, record the adhesive limit as greater than the tensile strength of the sheeting.

(d) Repeat the test with the other four test panels.

(e) Record the adhesive limit as being either—

  (i) whether all test pieces broke before peeling; or

  (ii) the minimum force expressed in newtons per millimetre width at which any that did not break, peeled from the test panel.

H5 REPORT

The following shall be reported:

(a) The manufacturer's name, and the class and colour of the sheeting.

(b) The adhesive limit of the five sheeting samples given in Paragraph H4 including whether the test piece broke before peeling.

(c) Any tearing, breaking or removal of adhesive material during liner removal when preparing test pieces as specified in Paragraph H4(a).

(d) The name of the test laboratory or authority responsible for performing the tests.

(e) A reference to this test method, i.e. AS/NZS 1906.1, Appendix H.

APPENDIX I

DURABILITY TESTS

(Normative)

I1 SCOPE

This Appendix sets out test procedures for durability assessment by the following means:

(a) Outdoor accelerated weathering—Fixed rack method.

(b) Outdoor accelerated weathering—Moving rack method.

The test in Item (b) is optional only (see Clause 2.6.1).

I2 OUTDOOR ACCELERATED WEATHERING TEST

I2.1 Exposure racks

Test racks shall be positioned clear of shadow areas so that the maximum amount of available sunlight falls on the test pieces.

NOTE: An example of a suitable location for test racks to ensure testing is completed within a reasonable time is a site near the coast of North Queensland within 40 km of latitude 19°30' S and longitude 146°50' E.

The frame or rack shall be constructed so that contamination of the test panel by rust, stain or other products of corrosion from its structural components will be avoided. Test panels shall be readily removable without mechanical damage for cleaning and testing purposes.

Test racks shall be constructed as follows:

(a) *Fixed rack*

The rack shall be constructed so that test panels attached either directly or indirectly to it face due north and upwards at 45° to the vertical.

(b) *Moving rack*

The test rack to which test panels are attached either directly or indirectly shall be mounted on a moving support equipped with a tracking mechanism which allows radiant energy from the sun to strike test panels perpendicularly continuously throughout each day.

I2.2 Energy measurement

Each rack shall be equipped with an energy measurement device capable of cumulatively measuring received solar energy, in MJ/m^2, and positioned so that the surface is always in the same plane as the test panels.

I2.3 Test panel preparation

Test pieces of retroreflective sheeting shall be mounted as specified in Paragraph J3.1, on test panels having the relevant dimensions shown in Figure I1.

Each test panel shall be prepared so that—

(a) there is sufficient area of retroreflective sheeting to allow photometric tests as described in Appendix A to be carried out;

(b) two opposite sides of the reflective sheeting are flush with the edges of the panel;

(c) a clear space is left at the top and bottom of the panel; and

(d) the panel is unambiguously coded for later identification, preferably by metal punching or engraving.

I2.4 Procedure

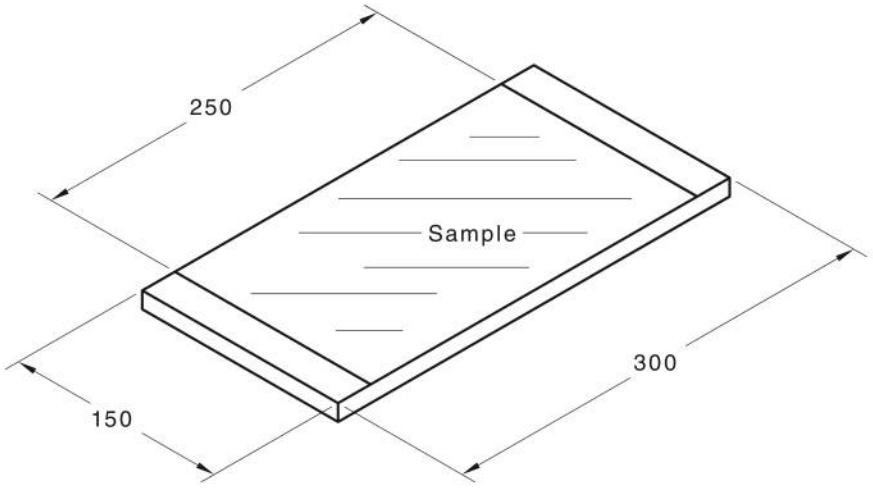
The procedure shall be as follows:

(a) Expose test pieces until they have received the radiant energy as listed in Table 2.10.

Each of the radiant energy values shall be subject to a tolerance of –0, +5%.

NOTE: It is expected that a fixed rack exposure period of about one year will be required for each 7500 MJ/m^2 received and about 8 months for moving rack exposure.

(b) At the conclusion of the appropriate exposure period, remove the test pieces from the racks, clean carefully with a mild detergent solution, and subject them to the examination and tests prescribed in Clause 2.6.2.



DIMENSIONS IN MILLIMETRES

FIGURE I1 TEST PANEL BASE FOR RETROREFLECTIVE SHEETING

I3 REPORT

The following shall be reported:

(a) The manufacturer's name, class and colour of the sheeting.

(b) Whether the test piece is removable from the test panel without damage.

(c) Any evidence of cracking, crazing, peeling, blistering or delamination of the test piece.

(d) The amount of applied shrinkage or edge lifting on any edge (if any).

(e) Any evidence of edge damage or corrosion extending more than an average of 1 mm, or 4 mm at any one point, into the sheeting from the edge,(excluding non-functioning of cells in cellular sheeting which have been cut or damaged during preparation of the test piece.)

(f) The name of the test laboratory or authority responsible for performing the tests.

(g) A reference to this test method, i.e. AS/NZS 1906.1, Appendix I.

APPENDIX J

PREPARATION OF TEST PIECES

(Normative)

J1 SCOPE

This Appendix sets out requirements for conditioning of test pieces prior to testing, and their mounting on a metallic substrate where required for a particular test.

J2 CONDITIONING OF TEST PIECES

Unless otherwise specified in a particular test, where conditioning of test pieces is required prior to testing in any of the tests prescribed in this Standard, the conditioning shall consist of the storing of the specimen at 23 ±3°C and 50 ±5% relative humidity for at least 24 h. The subsequent test shall be carried out at the same temperature and relative humidity unless otherwise specified in a particular test. Before conditioning, test pieces shall have any surface contamination removed by washing with a mild detergent.

J3 MOUNTING OF TEST PIECES

J3.1 Physical property and adhesion tests for adhesive backed samples

Where tests prescribed in Paragraphs F3, F4 and in Appendix H are to be performed using a test piece mounted on a substrate, the test piece shall be applied to a stainless steel plate to ASTM A240M. Material supplied as bright annealed (304 BAPC) 0.9 mm thick meets this requirement. The test sheeting shall be applied so that there are no creases, bubbles or wrinkles in the sheeting.

J3.2 Physical property and adhesion tests for non-adhesive backed samples

J3.2.1 *General*

Cut out the sample to the required size without breaking any welded cell seams, and then mount each of the tests as prescribed below.

J3.2.2 *For photometric, rainfall, solvent resistance and colour tests*

Attach sample without stretching or wrinkling to a flat backing plate at least 1.6 mm thick using double sided adhesive tape.

J3.2.3 *For outdoor exposure testing*

Samples shall be prepared as follows:

(a) Cut a sample of the required size ensuring that no welded seams are cut to allow the ingress of moisture or dirt.

(b) Cut or punch four holes in the corners of the sheeting to accommodate pop rivets. Drill the backing plate and pop rivet the sample to the plate at the corners ensuring the sample is flat but not stretched.

(c) Other methods of attachment may be used if long term performance data shows that the means of attachment does not have a detrimental effect on the sample.

J3.3 Other tests

For tests prescribed in Appendices A, C, E and I, the substrate shall be a flat surface of suitable rigidity, e.g. a 1.6 mm thick panel of aluminium. The test sheeting shall be applied using processes recommended by the sheeting manufacturer for its normal in-service use.

APPENDIX K

APPLICATION OF UNCERTAINTY OF MEASUREMENT

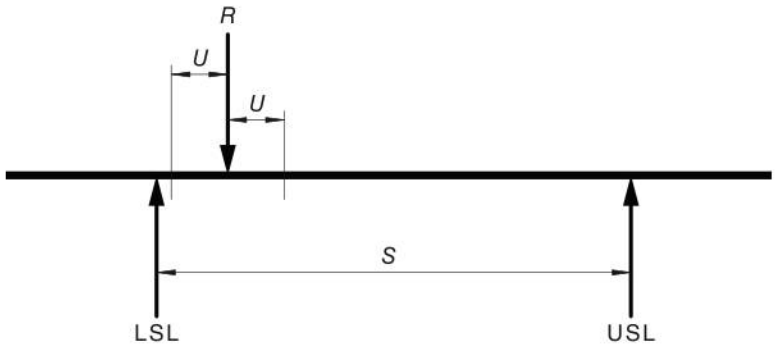
(Normative)

K1 SCOPE

In order to determine conformance or otherwise of the measurement made in accordance with the test methods when compared to the specification limits, the following protocol shall be applied.

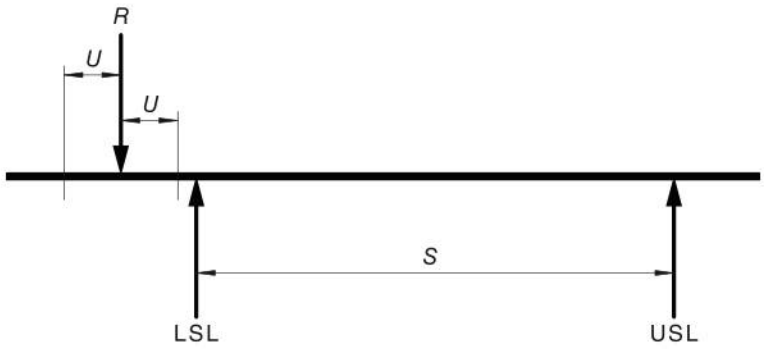
K2 METHOD

If the test result plus or minus the uncertainty of measurement, *U*, falls completely inside or outside the specification zone for the particular test given in the Standard, then the result shall be deemed to be a straightforward pass or fail (see Figures K1 and K2).



LEGEND:
R result of a measurement
S specified performance guidelines
LSL lower specified limit
USL upper specified limit
U uncertainty of measurement

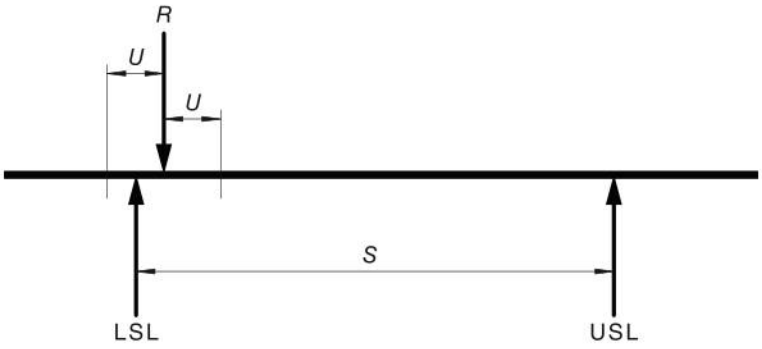
FIGURE K1 PASS RESULT



LEGEND:
R result of a measurement
S specified performance guidelines
LSL lower specified limit
USL upper specified limit
U uncertainty of measurement

FIGURE K2 FAIL RESULT

If the test result plus or minus the uncertainty of measurement, U, overlaps a specification limit value (upper or lower) for the particular test given in the Standard, then the assessment shall be reported as uncertain (see Figures K3 and K4) and the determination of conformance is left to the road controlling authorities.



LEGEND:
R result of a measurement
S specified performance guidelines
LSL lower specified limit
USL upper specified limit
U uncertainty of measurement

FIGURE K3 UNCERTAIN RESULT

LEGEND:
R result of a measurement
S specified performance guidelines
LSL lower specified limit
USL upper specified limit
U uncertainty of measurement

FIGURE K4 UNCERTAIN RESULT

NOTES

NOTES

NOTES

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Standards Australia is an independent company, limited by guarantee, which prepares and publishes most of the voluntary technical and commercial standards used in Australia. These standards are developed through an open process of consultation and consensus, in which all interested parties are invited to participate. Through a Memorandum of Understanding with the Commonwealth government, Standards Australia is recognised as Australia's peak national standards body.

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