

Australian/New Zealand Standard™

**Retroreflective materials and devices for
road traffic control purposes**

**Part 4: High-visibility materials for safety
garments**



AS/NZS 1906.4:2010

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Australian/New Zealand Standard™

Retroreflective materials and devices for road traffic control purposes

Part 4: High-visibility materials for safety garments

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee MS-049, Retroreflective Devices and supersedes AS/NZS 1906.4:1997, *Retroreflective materials and devices for road traffic control purposes*, Part 4: *High visibility materials for safety garments*. It is one of a series of four Standards as follows:

AS

1906 Retroreflective materials and devices for road traffic control purposes

1906.3 Part 3: Raised pavement markers (retroreflective and non-retroreflective)

AS/NZS

1906 Retroreflective materials and devices for road traffic control purposes

1906.1 Part 1: Retroreflective sheeting

1906.2 Part 2: Retroreflective devices (non-pavement application)

1906.4 Part 4: High visibility materials for safety garments (this Standard)

This Standard covers only high-visibility materials to be used in the manufacture of safety garments, rather than the garments themselves. Requirements for high-visibility garments are specified in AS/NZS 4602.1, *High visibility safety garments, Part 1: Garments for general use*.

The principal changes from the 1997 edition of this Standard are as follows:

- (a) The photometric performance required of Class RF combined performance retroreflective/fluorescent material has been raised to the same level as other retroreflective materials.
- (b) The testing of daylight colour and luminance factor of fluorescent materials has been refined and now makes provision for use of the double monochromator method where warranted.
- (c) The test for daylight colour retention in fluorescent materials when wet, has been made optional.
- (d) A clause relating to the acceptance of background material supplied from overseas has been deleted.

EN 471, *High-visibility warning clothing for professional use—Test methods and requirements*, was consulted in the preparation of this Standard.

The term 'normative'⁹ has been used in this Standard to define the application of the appendix to which it applies. A 'normative'⁹ appendix is an integral part of a Standard.

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FOREWORD

High daytime visibility for safety garments is normally achieved through the use of fluorescent materials. Fluorescent materials of recent manufacture have a very much longer life than could be achieved previously. However, they will fade over extended time periods. This loss of fluorescence can be measured by use of the test method described under colourfastness after UV exposure (Clause 2.5.1). This method also lends itself to measurements of samples that have been subjected to natural daylight for varying periods so that the ultimate in-service durability of the fluorescent effect in a sample of material – rather than simply its ability to meet the minimum requirements of this Standard, can be assessed.

The tolerances on the colour of high daytime visibility materials specified in this Standard are based on EN 471, *High-visibility warning clothing for professional use – Test methods and requirements*, but have been extended to include colours at both ends of the orange spectrum and at the lower end of the yellow spectrum.

Provision is made in the Standard for high-visibility non-fluorescent colours for use in those situations where, for safety reasons in a particular industry, natural fibres that will not adequately retain fluorescent colour must be used in safety garments. However, users are warned that such colours will rarely be as effective visually by day as fluorescent colours, and their use should be restricted to those situations where synthetic fabrics carrying fluorescent colour cannot be used.

Retroreflected colour is not specified for retroreflective materials. In line with the philosophy on which EN 471 is based, the essential night-visibility requirement for high-visibility garment material is an absolute retroreflective performance regardless of colour. Although, in practice, materials that reflect either white or yellow are more likely to meet the higher retroreflective performance specified, other colours are not precluded if they are capable of meeting that performance.

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Retroreflective materials and devices for road traffic control purposes

Part 4: High-visibility materials for safety garments

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the photometric, colorimetric and physical property requirements for high-visibility materials for outdoor daytime use, or retroreflective materials for use at night or in other dark conditions to be used for the manufacture of, or for incorporation into industrial safety garments designed to be worn in situations where the wearer needs to be highly visible. Immersible water safety materials such as those used on personal flotation devices are not included.

NOTE: This Standard does not include requirements for the integrity or performance of materials under extremes of temperature, atmospheric conditions, abrasive conditions or any other abnormal use of the material.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1441	Methods of test for coated fabrics
1441.14	Part 14: Method for determination of resistance to cold cracking NOTE: This Standard has been withdrawn but may continue to be used pending publication of a replacement Standard.
2001	Methods of test for textiles
2001.2.25.1	Part 2.25.1: Physical tests – Determination of the abrasion resistance of fabrics by the Martindale method—Martindale abrasion testing apparatus
2001.4.1	Part 4.1: Colourfastness tests—Definitions and general requirements
2001.4. B02	Part 4.B02: Colourfastness tests—Colourfastness to artificial light: Xenon arc fading lamp test (ISO 105-B02:1994, MOD)
2001.4. E04	Part 4.E04: Colourfastness tests—Determination of colourfastness to perspiration
2001.4.15	Part 4.15: Colourfastness tests—Determination of colourfastness to washing
2001.5.4	Part 5.4: Dimensional change—Domestic washing and drying procedures for textile testing (ISO 6330:2000, MOD)
4004	Lighting booths for visual assessment of colour and colour matching
4878	Methods of test for coated fabrics
4878.9	Part 9: Determination of resistance to damage by flexing
AS/NZS	
1906	Retroreflective materials and devices for road traffic control purposes
1906.1	Part 1: Retroreflective sheeting
1957	Textiles—Care labelling

CIE	
54	A method of assessing the quality of daylight simulators for colourimetry
54.2	Part 2: Retroreflection—Definition and measurement

1.3 DEFINITIONS

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

1.3.1 Viewing geometry

NOTES:

- 1 The following are condensed versions of the corresponding definitions given in CIE 54.2. Reference should be made to the CIE document if a full set of parameters and their definitions is required.
- 2 An illustration showing the parameters below can be found in AS/NZS 1906.1.

1.3.1.1 Entrance angle (j_i)

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

The angle p has two components, p_1 and p_2 as follows:

- (a) p_1 is the component projected onto the plane containing the observation angle.
- (b) p_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.

NOTE: Since this Standard specifies that all CIL/m² measurements are to be taken with the plane containing the entrance angle in the same plane as the observation angle, the CIL/m² tabulations in Section 2 will show $p_2 = 0$.

1.3.1.2 Observation angle (a)

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

1.3.1.3 Rotation angle (e)

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

1.3.2 Light technical parameters

1.3.2.1 Coefficient of luminous intensity (CIL)

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. It is referred to as the 'CIL value'.

NOTE: This coefficient is applicable to devices that are effectively point sources of light at normal viewing distances.

1.3.2.2 Coefficient of luminous intensity per unit area

The value expressed in candela per lux per square metre (cd.lx⁻¹.m⁻²), obtained by dividing the coefficient of luminous intensity of a test piece by the area in square metres of that test piece measured parallel to its surface. It is referred to as the 'CIL/m value'.

1.3.2.3 *Luminance factor*

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 usually expressed as a decimal in the range 0 to 1 but values greater than 1 are possible for some fluorescent materials. It may also be expressed as a percentage.

1.3.3 **Material performance parameters**

1.3.3.1 *Orientation sensitive material*

Retroreflective material that exhibits CIL/m^2 values that differ by more than 15 percent when measured at any two rotation angles 90° apart and at entrance angle $\alpha = 20^\circ$ and observation angle $\beta = 0.2^\circ$.

1.3.3.2 *Fluorescent material*

Material that emits optical radiation at wavelengths longer than absorbed.

1.4 **CLASSIFICATION OF MATERIALS**

High-visibility materials shall be classified according to their day or night-time application, as follows:

- (a) *Class F* High daytime visibility fluorescent material.
- (b) *Class F (W)* High daytime visibility fluorescent material that has met both the requirements for Class F material and an optional wet weather test (see Clause 2.6).
- (c) *Class R* Retroreflective material for use on garments used in dark conditions.
- (d) *Class RF* Combined performance retroreflective/fluorescent material meeting all of the requirements of Class R and the daytime colour of Class F.
- (e) *Class NF* High daytime visibility non-fluorescent material.

SECTION 2 HIGH DAYTIME VISIBILITY MATERIALS CLASSES F, RF AND NF

2.1 APPLICATION OF SECTION

The requirements of this Section shall apply to Class F, Class RF and Class NF in respect of their daytime visibility only.

2.2 GENERAL DESCRIPTION AND SUMMARY OF TEST REQUIREMENTS

2.2.1 Class F and Class NF materials

Class F and NF materials typically comprise but are not limited to, either of the following:

- (a) A robust woven fabric of cotton, linen or equivalent man-made fibres to which a fluorescent or other highly coloured plastic coating has been applied.
- (b) A robust woven or knitted fabric of cotton or equivalent man-made fibre which contains a fluorescent colour or, if indicated in Clause 2.4, other high-visibility colour.

Class F and Class NF materials shall be subjected to the following tests:

- (i) Daylight colour and luminance factor test (see Clauses 2.3, 2.4 and Appendix A).
- (ii) Colourfastness after UV exposure (see Clause 2.5.1 and AS 2001.4.B02).
- (iii) Colourfastness to washing test (see Clause 2.5.2 and AS 2001.4.15).
- (iv) Colourfastness to perspiration test (see Clause 2.5.3 and AS 2001.4.E04).

A fresh sample of material shall be used for each test.

A Class F material which has met the optional wet weather test in Clause 2.6 may be designated Class F (W).

NOTE: This Standard specifies only those requirements related to the visibility and possible degradation of visibility, of materials. These tests do not address the durability or fitness for purpose of the materials in other respects.

2.2.2 Class RF materials

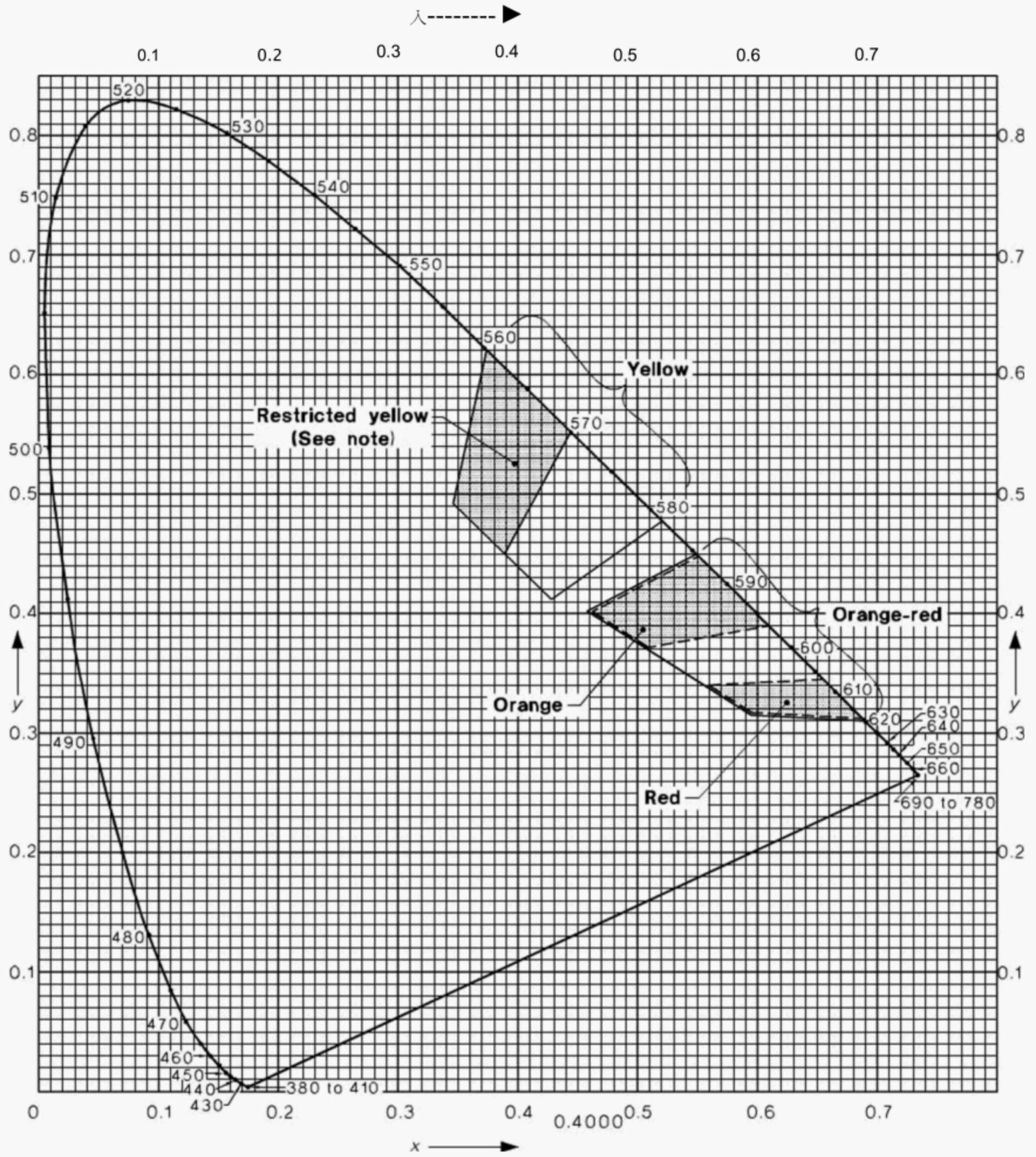
Class RF materials are required only to meet the fluorescent colour requirement of Clause 2.3. In all other respects they are required to meet the requirements of Section 3 for a retroreflective material.

2.3 FLUORESCENT COLOUR

The colour and luminance factor of fluorescent material when tested under simulated daytime conditions in accordance with Appendix A shall conform to the following requirements:

- (a) The chromaticity coordinates of the test piece shall be within the corresponding colour space defined by the coordinates of the corners of the space as given in Table 2.1 and illustrated in Figure 2.1.
- (b) The minimum luminance factor of a test piece shall be as specified in Table 2.2 for the colour to which it conformed in the test in Item (a) above.

NOTE: Separate specifications have been provided for the colours orange and red for the benefit of industries that require the distinction for colour coding purposes. They have been derived from an arbitrary division of the orange-red colour space as illustrated in Figure 2.1. Purchasers who require the two distinctive colours are advised to ensure that when offered otherwise conforming materials, the perceived colour difference is adequate for their purposes.



NOTE: Use of the colour yellow in this colour space is to be preferred. See also Note 3 to Table 2.1.

FIGURE 2.1 CIE CHROMATICITY LIMITS (COLOURS SPACES) FOR HIGH DAYTIME VISIBILITY COLOURS

TABLE 2.1
CIE CHROMATICITY COORDINATES (x^{\wedge}) OF THE CORNERS OF THE
COLOUR SPACES FOR HIGH DAYTIME VISIBILITY MATERIALS
(see also Figure 2.1)

Colour	Chromaticity coordinates (CIE2° Standard observer, CIE Illuminant D ₆₅ , Instrument configuration 45°/0° or 0°/45°)				
	x	y	z	w	v
Fluorescent orange-red	x	0.690	0.595	0.458	0.550
	y	0.310	0.315	0.404	0.450
Fluorescent yellow (see Note 1)	x	0.520	0.428	0.346	0.375
	y	0.477	0.412	0.492	0.625
Fluorescent red (see Note 2)	x	0.655	0.555	0.595	0.690
	y	0.345	0.340	0.315	0.310
Fluorescent orange (see Note 2)	x	0.610	0.550	0.458	0.506
	y	0.390	0.450	0.404	0.371
Fluorescent yellow restricted (see Note 3)	x	0.460	0.390	0.346	0.375
	y	0.540	0.450	0.492	0.625

NOTES:

- 1 The colour space for yellow includes the colours commonly known as 'lime-yellow' and 'yellow-green'.
- 2 The separate colours red and orange have been provided for use in industries that require a distinction for colour coding purposes. Both colours lie within the colour space for orange-red.
- 3 The restricted yellow is the preferred colour wherever yellow or fluorescent yellow is specified. It can be anticipated that in future editions of this Standard the colour yellow will be confined to this colour space.

TABLE 2.2
MINIMUM LUMINANCE FACTOR FOR
FLUORESCENT COLOURS

Colour designation	Minimum luminance factor (CIE2° Standard observer, CIE Illuminant D ₆₅ , Instrument configuration 45°/0° or 0°/45°)
Fluorescent orange-red	0.40
Fluorescent red	0.25
Fluorescent orange	0.40
Fluorescent yellow	0.70

NOTE: Users should be aware that certain open-weave materials, when tested in accordance with Appendix A may not meet the minimum luminance factors specified above.

2.4 NON-FLUORESCENT COLOUR

Where for safety reasons a garment must be made from a natural fibre incapable of retaining a fluorescent colour, Class NF high-visibility non-fluorescent coloured material whose chromaticity coordinates lie within the same colour spaces specified in Table 2.1 for fluorescent colours may be substituted. The colour of non-fluorescent materials when tested under simulated daytime conditions in accordance with Appendix A shall conform to the same requirements as specified for fluorescent materials in Clause 2.3, except that the minimum luminance factor for each colour shall be as specified in Table 2.3.

NOTE: Users should be aware that such materials may not have the long-distance visibility of fluorescent materials in daylight, and should limit accordingly the circumstances under which they are used.

TABLE 2.3
MINIMUM LUMINANCE FACTOR FOR HIGH-VISIBILITY
NON-FLUORESCENT COLOURS

Colour designation	Minimum luminance factor (CIE2° Standard observer, CIE Illuminant D ₆₅ , Instrument configuration 45°/0° or 0°/45°)
Red, orange-red	0.15
Orange	0.30
Yellow	0.40

2.5 DURABILITY

2.5.1 Colourfastness after UV exposure

The colourfastness of the material UV exposure shall be determined in accordance with AS 2001.4.B02, Method 5. Exposure shall be continued until the test specimen has been exposed to 225 kJ.m⁻². When tested in accordance with Appendix A the colour and luminance factor after exposure shall be within the areas specified by the chromaticity coordinates in Table 2.1 and shall meet the minimum luminance factor specified in Table 2.2 for fluorescent or Table 2.3 for non-fluorescent materials.

2.5.2 Colourfastness to washing

When tested in accordance with AS 2001.4.15, TestL2, the material shall show no greater colour change than 4 on the grey scale. The grey scale comparison shall be made in accordance with AS 2001.4.1, except that the assessment is to be carried out in a colour matching booth complying with AS 4004, Category BC.

2.5.3 Colourfastness to perspiration

When tested in accordance with AS 2001.4.E04, the material shall show no greater colour change than 4 on the grey scale. The grey scale comparison and assessment shall be carried out as specified in Clause 2.5.2.

2.6 WET WEATHER PERFORMANCE (OPTIONAL)

An optional wet weather performance test may be carried out on Class F materials. A sample, after immersion in distilled water at 20° ± 5°C for 5 ± 2 min and then allowed to drain naturally for 5 ± 2 min that then meets all of the requirements of Clause 2.3, except for a reduction in luminance factor to not less than 85 percent of that specified in Table 2.3, shall be deemed to have passed this test. This material may then be classified Class F (W) material.

NOTES:

- 1 The purpose of the optional classification is to allow garments made from such materials to be described as suitable for wet weather use, e.g. rainwear.
- 2 The rainfall performance in Clause 3.8 for retroreflective materials is not optional. All Class R and RF materials are expected to meet that test requirement

**SECTION 3 RETROREFLECTIVE MATERIALS
CLASSES R AND RF**

3.1 APPLICATION OF SECTION

The requirements of this Section shall apply to Class R and Class RF materials in respect of their retro reflective properties for night-time use.

3.2 GENERAL DESCRIPTION AND SUMMARY OF TEST REQUIREMENTS

Class R and Class RF retroreflective materials typically comprise but are not necessarily limited to a flexible fabric, plastic film or film system incorporating retroreflective elements of either the exposed lens, the enclosed lens, the encapsulated lens or the microprismatic type.

Class R and Class RF materials shall be subjected to the tests listed in Table 3.1.

**TABLE 3.1
SUMMARY OF TESTS REQUIRED FOR CLASS R AND CLASS RF MATERIALS**

Test	References
Minimum photometric performance	Clause 3.3 and AS/NZS 1906.1
Daytime colour	Clause 3.4—Class RF only
Exposure to UV light test (for loss of CIL)	Clause 3.5.2, AS 2001.4.B02 and AS/NZS 1906.1
Washing test (for loss of CIL)	Clause 3.5.3, AS 2001.5.4 and AS/NZS 1906.1
Abrasion test	Clause 3.5.4, Appendix B, AS 2001.2.25.1 and AS/NZS 1906.1
Raised temperature test	Clause 3.5.5 and AS/NZS 1906.1
Resistance to flexing	Clause 3.6 and AS 4878.9
Resistance to cold cracking	Clause 3.7 and AS 1441.14
Rainfall performance	Clause 3.8 and AS/NZS 1906.1

3.3 MINIMUM PHOTOMETRIC PERFORMANCE FOR CLASS R AND CLASS RF SERIES MATERIALS

When tested for photometric performance in accordance with AS/NZS 1906.1, a new clean test piece material shall attain CIL/m² values as detailed in Table 3.2.

Orientation sensitive material (see Clause 1.3.3.1) shall comply with the minimum requirements for the CIL/m detailed in Table 3.2 at one of the two rotation angles (e) = 0° or (e) = 90° as appropriate at each of the entrance and observation angles specified in the Table. Additionally, the CIL/m shall be not less than 75 percent of those requirements at the other rotation angle.

The rotation angle ⁽⁴⁾=0° shall be determined by one of the following means:

- (a) A datum mark incorporated into the material.
- (b) A clear instruction given by the manufacturer of the material.

If no mark or instruction is given, the rotation angle shall be measured from the longitudinal centre line of the tape.

NOTE: Mounting of test pieces for this test strictly in accordance with AS/NZS 1906.1 may not be practicable for fabric type materials. They will usually require a clamping mask for mounting on a rigid substrate, and should not be stretched during mounting. Use of adhesives for mounting test pieces should be carefully evaluated prior to use as some adhesives will adversely affect test pieces stored for an extended period.

TABLE 3.2
MINIMUM COEFFICIENTS OF LUMINOUS
INTENSITY PER UNIT AREA FOR
CLASS R AND CLASS RF SERIES MATERIALS

Entrance angle (p_1) (p_2 = 0) degrees	Observation angle (a) degrees	Minimum CIL/m ² values cd.lx ⁻¹ .m ⁻²
5	0.2	330
	0.33	250
	1.0	25
	1.5	10
20	0.2	290
	0.33	200
	1.0	15
	1.5	7
30	0.2	180
	0.33	170
	1.0	12
	1.5	5
40	0.2	65
	0.33	60
	1.0	10
	1.5	4

3.4 COLOUR

Daylight colour requirements are specified for Class RF only, see Clause 2.3.

NOTE: The retroreflected colour is not specified for any Class R or Class RF material. In practice, only lighter colours are likely to meet the photometric performance requirements, see Foreword.

3.5 DURABILITY TESTS

3.5.1 Test sample selection and conditioning

Unless otherwise specified in a particular test, where conditioning of test pieces is required for testing in any of the tests prescribed in this Standard, the conditioning shall consist of maintaining the specimen at $20^\circ \pm 2^\circ\text{C}$ and 65 ± 5 percent relative humidity for 24 h. The subsequent test shall be carried out at the same temperature and relative humidity unless otherwise specified in a particular test. Fresh samples shall be used for each test.

3.5.2 Exposure to UV light (retention of CIL) test

When samples of material are exposed in the UV light exposure apparatus and according to the procedure described in AS 2001.4.B02, Method 5 until they have been exposed to 225 kJ.m^{-2} , they shall have a CIL/m² value not less than $100 \text{ cd.lx}^{-1}.\text{m}^{-2}$ when measured at 5° entrance angle and 0.2° observation angle in accordance with AS/NZS 1906.1.

3.5.3 Washing tests

When samples of material are subjected to 5 wash/diy cycles to Test 2A as specified in AS 2001.5.4, and then to Drying Procedure V (warm tumble-dry) they shall have a CIL/m value not less than $100 \text{ cd.lx}^{-1}.\text{m}^{-2}$ when measured at an entrance angle of 5° and an observation angle 0.2° in accordance with AS/NZS 1906.1.

3.5.4 Abrasion test

When subjected to the abrasion test in Appendix B, the material shall have a CIL/m value not less than $100 \text{ cd.lx}^{-1}.\text{m}^{-2}$ when measured at an entrance angle of 5° and an observation angle 0.2° in accordance with AS/NZS 1906.1.

3.5.5 Raised temperature test

When subjected to the raised temperature test in Appendix C, the material shall show no physical damage, such as peeling, cracking or delamination likely to affect their utility as part of a garment, no migration of colour which would affect their visual performance as part of a garment, and shall retain a CIL/m² value not less than $100 \text{ cd.lx}^{-1}.\text{m}^{-2}$ when measured at 5° entrance angle and 0.2° observation angle in accordance with AS/NZS 1906.1.

3.6 RESISTANCE TO FLEXING

Materials which comprise either a high-visibility material bonded to a fabric substrate or other laminated construction shall, when subjected to the resistance to flexing test in AS 4878.9 Method B, show no signs of cracking after 7 500 cycles.

3.7 RESISTANCE TO COLD CRACKING

Materials which comprise either a high-visibility material bonded to a fabric substrate or other laminated construction shall, when subjected to the cold cracking test in AS 1441.14, show no signs of cracking or flaking.

3.8 RAINFALL PERFORMANCE

Retroreflective material shall be tested for rainfall performance in accordance with AS/NZS 1906.1. The CIL/m² value of the material when measured at an entrance angle of 5° and an observation angle of 0.2° in accordance with AS/NZS 1906.1 shall be not less than $100 \text{ cd.lx}^{-1}.\text{m}^{-2}$.

SECTION 4 MATERIAL CARE AND MARKING

NOTES:

- 1 Materials should be packaged as to ensure adequate protection against physical damage in storage and transit before delivery.
- 2 The material should be capable of withstanding storage for at least 12 months at normal store temperatures likely to be encountered in Australia or New Zealand, or as otherwise recommended by the manufacturer, without loss of adhesion, flexibility, or other properties as specified herein.

4.1 CARE LABELLING

Information shall be provided which will enable a garment manufacturer to provide correct care labelling on garments in accordance with AS/NZS 1957.

NOTE: Such information should include the need for a warning against leaving garments in sunlight inside vehicles in hot conditions where such conditions could cause damage to the material.

4.2 MARKING

Packages containing materials shall be durably marked with the following information:

- (a) The manufacturer's name or trade mark.
- (b) Product designation, i.e. material class, colour, identification number, and size of roll or sheet.
- (c) Production batch number.

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

APPENDIX A

DAYLIGHT COLOUR AND LUMINANCE FACTOR TESTS—FLUORESCENT
AND NON-FLUORESCENT MATERIALS

(Normative)

A1 SCOPE

This Appendix sets out methods for measuring colour chromaticity coordinates and luminance factor for Class F, Class RF and Class NF materials, i.e. all materials required to have a high visibility daytime colour, both fluorescent and non-fluorescent.

NOTE: Retroreflected colour of Classes R and RF is not specified in this Standard.

A2 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 D_{65} and measuring the colorimetric tristimulus values using a spectrophotometer with a spectral analysing unit. This method is suitable for the absolute measurement of non-fluorescent material and may be used for the measurement of fluorescent material. 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 material.
- (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 (x,y) can then be calculated for CIE Illuminant D_{65} . The total luminance factor (γ_t) is determined with the use of a calibrated reflectance tile. This method is suitable for use for referee purposes for the measurement of fluorescent material.

NOTE: This method is suitable for calculating separately the luminance factor due to fluorescence alone (γ_F).

A3 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 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.

A4 INSTRUMENTATION

Instrumentation shall comprise the following:

- (a) Spectroradiometer 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 (settable within 0.2 nm).
- (c) Light source which closely matches the CIE Illuminant D₆₅. If the source is to be used to measure the colour and luminance factor of fluorescent material by the single monochromator method, it shall be calibrated in accordance with CIE 51 so as to achieve Category BC as described in that publication.
- (d) Instrument geometry either 45°ring/0°, 45°/0° or 0°/45° (see Note 1). The tolerance on the inclination of the 45° axis shall be 2° (45° ±2°). The tolerance on the 0° axis shall be 2° from the normal (0° ±2°). The aperture sizes for the referee method shall be 10° for illumination and 10° for viewing. The use of aperture sizes deviating from these may affect the measurement result (see Note 2).

NOTES:

- 1 The use of instrument with 45°ring/0° geometry will facilitate the collection of consistent readings when measuring woven fabrics.
- 2 Whilst fluorescent colorimetric properties are not significantly influenced by the aperture size, reflectance colorimetric properties may be greatly influenced. Consequently total colorimetric properties may be greatly affected.

Alternatively a tristimulus colorimeter can be used for the measurement of non-fluorescent high visibility materials (Class NF) subject to the following:

- (i) The colorimeter shall be calibrated against a standard closely approximating the colour of the sample.
- (ii) The illuminating light source shall meet the requirements for illuminant D₆₅ set out in Paragraph A4(c).
- (iii) The instrument geometry shall be the same as set out in Paragraph A4(d).

A5 PROCEDURE

The procedure shall be as follows:

- (a) Place a single layer of the material, including any in-service backing or lining, on a flat neutral black matt surface of less than 5% diffuse reflectance. The sample shall be flat but not stretched.
- (b) If other than 45°ring/0° geometry is being used to measure a woven fabric, align the sample with the measuring instrument so that the plane which is normal to the sample and which contains the 45° axis is parallel to either the warp or the weft of the fabric.
- (c) Except as specified in Item (d), measure the colorimetric tristimulus values of the sample in at least three areas and determine the mean total luminance factor ($\bar{7}_t$) and chromaticity coordinates (\bar{x}, \bar{y}).
- (d) For cellular and other materials with a discontinuous surface, when measured with an instrument with a small field of view, so that the size of the cell or other discontinuity is appreciable compared to the field of view, obtain the mean of six reading of both chromaticity coordinates (\bar{x}^6, \bar{y}^6) and total luminance factor ($\bar{7}_t$) taken at different, randomly selected points over the surface to ensure that the measurements are representative of the sample as a whole.

A6 REPORT

The following shall be reported:

- (a) The manufacturer's name, class and colour of the material.
- (b) The test method, instrument geometry and light source used.
- (c) The chromaticity coordinates and luminance factor values.
- (d) The name of the organization carrying out the tests.
- (e) The date the tests were done.
- (f) A reference to this test method, i.e. Appendix A of AS/NZS 1906.4.

APPENDIX B

ABRASION TEST FOR RETROREFLECTIVE MATERIAL

(Normative)

B1 SCOPE

This Appendix sets out the test to be applied to retroreflective materials to determine their resistance to abrasion as it affects their photometric performance.

B2 PRINCIPLE

A sample of retroreflective material is placed in a scrubbing machine where it is subjected to a rubbing action by a weighted pad covered with a mildly abrasive fabric. The sample is then tested to determine loss of CIL.

B3 APPARATUS

The following apparatus is required:

- (a) *For conduct of the rubbing procedure*—a scrubbing machine comprising a 4000 mm (minimum) abrasion head covered with a 3 mm thick layer of foam over which is tightly drawn a covering of standard abradant fabric as specified in AS 2001.2.25.1. The abrasion head is attached to an oscillating arm so that an area 12 000 mm² (minimum) of the test piece, clamped horizontally, face up, is rubbed in a straight reciprocating motion. The abrasion head is weighted so as to apply a pressure of 1 ± 0.02 kPa to the test piece. The apparatus performs automatically a predetermined number of cycles at a rate of 40 to 60 cycles (80 to 120 rubs) per minute.
- (b) *For conduct of the CIL measurement*—a photometer and associated equipment as specified in AS/NZS 1906.1.

B4 TEST SPECIMEN

The test specimen shall comprise a sample of the material applied to a 1.6 mm (approx.) flat aluminium or stainless steel plate using a suitable adhesive. The test area shall be approximately 100 mm x 150 mm or as required by the dimensions of the scrubbing apparatus.

B5 PROCEDURE

The procedure shall be as follows:

- (a) Insert the test specimen in the scrubbing machine so that each oscillation of the pad bears entirely on the test surface for the whole of its travel.
- (b) Run the machine for 5000 cycles (10 000 rubs).
- (c) At the conclusion of the rubbing procedure, mask the surface of the test specimen using black tape, so that only material that has been in contact with the rubbing pad is left exposed.
- (d) Measure and calculate the area of the exposed area within the mask.
- (e) Determine the CFL/m² value at 5° entrance angle 0.2° observation angle in accordance with the photometric properties test specified in AS/NZS 1906.1 on the area of test material within the mask.

B6 REPORT

The following shall be reported:

- (a) The type of material, its colour, and the manufacturer's name and identification.
- (b) The sample number, if applicable.
- (c) The CIL value in candelas per lux per square metre.
- (d) The name of the organization carrying out the tests.
- (e) The date the tests were done.
- (f) A reference to this test method, i.e. Appendix B of AS/NZS 1906.4.

APPENDIX C

RAISED TEMPERATURE TEST FOR RETROREFLECTIVE MATERIAL

(Normative)

C1 SCOPE

This Appendix sets out the test to be applied to retroreflective materials to determine their resistance to a raised level of ambient temperature as it affects their physical condition and photometric performance.

C2 PRINCIPLE

A sample of retroreflective material is folded in a specified way, loaded between two rigid plates with a specified mass and subjected to a heating and cooling cycle to simulate adverse storage conditions. The sample is then examined for visible physical degradation and tested for loss of CIL.

C3 APPARATUS

The following apparatus is required:

- (a) For conduct of the heat cycling procedure—
 - (i) an oven capable of maintaining a temperature of $60^{\circ} \pm 1^{\circ}\text{C}$;
 - (ii) two rigid metal plates, each approximately 200 mm square; and
 - (iii) a mass which together with the metal plate to be used as the upper plate will total 1.0 ± 0.1 kg.
- (b) For conduct of the CIL measurement—
 - (i) a photometer and associated equipment as specified in AS/NZS 1906.1; and
 - (ii) a clamping mask suitable for mounting fabric type test pieces on the photometer test piece holder.

C4 TEST SPECIMEN AND CONDITIONING

The test specimen shall comprise a sample of the material 250 ± 10 mm in length and 50 ± 1 mm in width, conditioned for at least 10 h at 20°C to 25°C .

C5 PROCEDURE

The procedure shall be as follows:

- (a) Fold the sample in thirds with the reflective face innermost as shown in Figure C1.
- (b) Preheat the oven to $60^{\circ} \pm 1^{\circ}\text{C}$.
- (c) Place the folded sample between the two metal plates with the mass on top and place the assembly in the oven for $4 \text{ h} \pm 10 \text{ min}$.
- (d) Remove the sample from the oven and allow it to cool in an environment at 20°C to 25°C for between 4 h and 20 h.
NOTE: This edition of this Standard requires only one heating/cooling cycle.
- (e) Remove the mass and unfold the sample.
- (f) Record any physical damage to the retroreflective surface or other parts of the material during or after unfolding, or any colour change or colour migration.

Mount the specimen in the clamping mask and determine its CIL/m at 5° entrance angle and 0.2° observation angle in accordance with the photometric properties test specified in AS/NZS 1906.1.

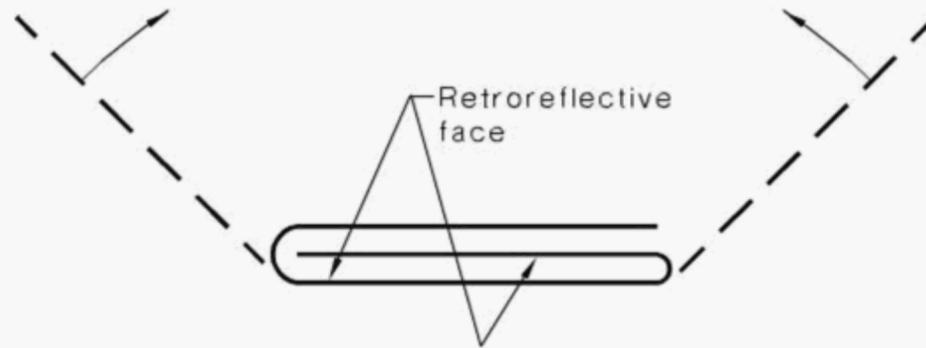


FIGURE C1 METHOD OF FOLDING SAMPLE

C6 REPORT

The following shall be reported:

- (a) The class of material, its colour, and the manufacturer's name and product identification.
- (b) A description of any physical damage to the material as a result of the test.
- (c) The CIL value in candela per lux per square metre.
- (d) The name of the organization carrying out the tests.
- (e) The date the tests were done.
- (f) A reference to this test method, i.e. Appendix C of AS/NZS 1906.4.

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