

93 Retro-reflective devices (RRD)

Refer to: R150 00

93.1 Effective date and Scope:

93.1.1 Effective date from 2025/1/1, following new types of devices shall comply with this regulation.

93.1.1.1 Retro-reflectors of the Classes IA, IB, IIIA, IIIB and IVA for vehicles of categories M, N, O and L.

93.1.1.2 Retro-reflective markings of the Classes C, D, E and F for vehicles of categories M, N and O.

93.1.1.3 Retro-reflective marking plates for Heavy and Long Vehicles of the Classes 1, 2, 3, 4 and 5 for vehicles of categories N2 with a maximum mass exceeding 7.5 tonnes and N3(except tractors for semi-trailers), vehicles of category O1, O2 and O3 exceeding 8.0 m in length and vehicles of category O4.

93.1.2 The applicants applying for low volume safety type approval may be exempt from “Retro-reflective devices” of this regulation except for large passenger vehicle and child-only vehicle.

93.1.3 Applying for vehicle-by-vehicle low volume safety type approval, the vehicle may be exempt from this regulation.

93.1.4 Technical Service can carry out test according to UN Regulations that this direction harmonized with: UN R150 00 Series of amendments and following amendments of above-mentioned regulations.

93.2 Definitions:

93.2.1 The definitions given in the VSTD of “The installation of lighting and light-signaling devices” in force at the time of application for type approval shall apply, unless otherwise specified.

93.2.2 CIE-Goniometer

93.2.2.1 Geometric definitions (see Figure 2)

93.2.2.1.1 Illumination axis (symbol I) means a line segment from the centre of reference to the light source.

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93.2.2.1.2 Observation axis (symbol O) means a line segment from the centre of reference to the photometer head.

93.2.2.1.3 Observation angle (symbol α) means the angle between the illumination axis and the observation axis. The observation angle is always positive and, in the case of retro-reflection, is restricted to small angles.

93.2.2.1.4 Observation on half-plane means the half-plane which originates on the illumination axis and which contains the observation axis.

93.2.2.1.5 Reference axis (symbol R) means a designated line segment originating on the centre of reference which is used to describe the angular position of the retro-reflective device.

93.2.2.1.6 Entrance angle (symbol β)" means the angle from the illumination axis to the reference axis. The entrance angle is usually not larger than 90 deg. but, for completeness, its full range is defined as $0 \text{ deg.} < \beta < 180 \text{ deg.}$ In order to specify the orientation in full, this angle is characterised by two components, β_1 and β_2 .

93.2.2.1.7 Rotation angle (symbol ε)" means the angle indicating the orientation of the retro-reflecting material by an appropriate symbol with respect to rotation about the reference axis. If retro-reflective materials or devices have a marking (e.g. TOP), this marking governs the starting position. The angle of rotation ε lies in the range $-180 \text{ deg.} < \varepsilon < +180 \text{ deg.}$

93.2.2.1.8 First axis (symbol 1) means an axis through the centre of reference and perpendicular to the observation half-plane.

93.2.2.1.9 First component of the entrance angle (symbol β_1)" means the angle from the illumination axis to the plane containing the reference axis and the first axis; range: $-180 \text{ deg.} < \beta_1 < 180 \text{ deg.}$

93.2.2.1.10 Second component of the entrance angle (symbol β_2) means the angle from the plane containing the observation half-plane to the reference axis; range $-90 \text{ deg.} < \beta_2 < 90 \text{ deg.}$

93.2.2.1.11 Second axis (symbol 2) means an axis through the centre of reference and perpendicular to both the first axis and

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the reference axis. The positive direction of the second axis lies in the observation half-plane when $-90 \text{ deg.} < \beta_1 < 90 \text{ deg.}$ as shown in Figure 2.

93.2.2.2 Definition of photometric terms

93.2.2.2.1 Coefficient of retro-reflection (symbol R') means the quotient of the coefficient of luminous intensity R of a plane retro-reflecting surface and its area A .

$$\left(R' = \frac{R}{A} \right)$$

The coefficient of retro-reflection R' is expressed in $\text{cd}/(\text{lx} \cdot \text{m}^2)$;

$$\left(R' = \frac{I}{E_{\perp} \cdot A} \right) \quad (\text{Luminance} / \text{Illumination});$$

93.2.2.2.2 Angular diameter of the retro-reflector sample (symbol η_1)" means the angle subtended by the greatest dimension of the retro-reflective sample, either at the centre of the source of illumination or at the centre of the receiver ($\beta_1 = \beta_2 = 0 \text{ deg.}$).

93.2.2.2.3 Angular diameter of the receiver (symbol η_2)" means the angle subtended by the greatest dimension of the receiver as seen from the centre of reference ($\beta_1 = \beta_2 = 0 \text{ deg.}$).

93.2.2.2.4 Luminance factor (symbol β)" means the ratio of the luminance of the body to the luminance of a perfect diffuser under identical conditions of illumination and observation.

93.2.2.2.5 Colour of the reflected light of the device means the definitions of the colour of the reflected light are given in paragraph 93.6.

93.3 Retro-reflective devices shall according to suitable type and range of principle :

93.3.1 The same brand

93.3.1.1 Retro-reflective devices bearing the same brand but produced by different manufacturers are considered as being of different types.

93.3.1.2 Retro-reflective devices produced by the same manufacturer differing only by the brand are considered as being of the same type.

In the case of a type of retro-reflective devices differing only by the brand (or mark) from a type that has already been approved it shall be sufficient to submit:

(a) A declaration by the lamp manufacturer that the type submitted is identical (except in the brand or mark) with and has been produced by the same manufacturer as the type already approved, the latter being identified by its approval code.

(b) Two samples bearing the new brand name or mark or equivalent documentation.

93.3.2 The same characteristics of the retro-reflective material.

93.3.3 The same characteristics of the fluorescent material.

93.3.4 The same parts affecting the properties of the retro-reflective materials and/or plates.

93.3.5 The same distinctive geometrical and mechanical features of the design (only for plates/devices corresponding to the paragraph 93.7)

For materials and/or plates corresponding to the paragraph 93.7, differences in the shape and dimensions of the marking shall not constitute a different type.

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93.4 General requirements

93.4.1 Retro-reflectors, retro-reflective materials or marking plates for general descriptions herein after referred to as "retro-reflective devices".

93.4.1.1 Retro-reflective devices shall be so constructed that they function satisfactorily and will continue to do so in normal use. In addition, they must not have any defect in design or manufacture that is detrimental to their efficient operation or to their maintenance in good condition.

93.4.1.2 The components of retro-reflective devices or parts thereof shall not be capable of being easily dismantled.

93.4.1.3 The means of attachment of the marking materials shall be durable and stable.

93.4.1.4 The outer surface of retro-reflective devices shall be easy to clean. The surface shall therefore not be rough and any protuberances they may exhibit shall not prevent easy cleaning.

93.4.1.5 There shall be no access to the inner surface of the retro-reflectors when in normal use.

93.4.1.6 Retro-reflective devices may consist of a combined retro-reflecting optical unit and filter, which must be so designed that they cannot be separated under normal conditions of use.

93.4.1.7 The colouring of retro-reflecting optical units and filters by means of paint or varnish is not permitted.

93.4.2 Colorimetric test conditions

93.4.2.1 Test procedure for night time colours:

93.4.2.1.1 These specifications shall apply only to clear, red or amber retro-reflective devices.

93.4.2.1.2 For testing the colour of the retro-reflective device, this device shall be illuminated by the CIE Standard Illuminant A, with an angle of divergence of $1/3$ degrees and an illumination angle of $V = H = 0$ degree, or, if this produces a colourless surface reflection, an angle $V = \pm 5$ degrees, $H = 0$ degree, the trichromatic coordinates of the reflected

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luminous flux must be within the limits according to the specifications for the individual retro-reflecting device in paragraph 93.4.

93.4.2.1.3 Clear retro-reflective devices must not produce a selective reflection, that is to say, the trichromatic coordinates "X" and "Y" of the standard illuminant "A" used to illuminate the retro-reflective device must not undergo a change of more than 0.01 after reflection by the retro-reflective device.

93.4.2.2 Test procedure for day time colours:

93.4.2.2.1 For testing the day time colour of the materials, the material shall be illuminated by the CIE Standard Illuminant D 65 at an angle of 45 deg. to the normal and viewed (measured) along the normal (45/0 geometry), with a spectrophotometer in accordance with the provisions of CIE document No. 15 (1971).

93.4.2.3 Test procedure for fluorescent colours:

93.4.2.3.1 Colour of the fluorescent material without retro-reflection:

93.4.2.3.1.1 For testing the colour of the fluorescent material, the material shall be illuminated by the CIE Standard Illuminant D65 (ISO 11664-2:2007(E)/CIE S 014-2/E:2006) and measured with a spectrophotometer in accordance with the provisions of Publication CIE 15:2004, Recommendations on Colorimetry - Second Edition, either illuminated polychromatically or with a monochromator providing stepwise the CIE Standard Illuminant D 65 (ISO 11664-2:2007(E)/CIE S 014-2/E:2006) at an angle 45 deg. to the normal and viewed along the normal (geometry 45/0). In the latter case, the stepwise resolution $\Delta\lambda$ shall be not larger than 10 nm.

Alternatively, similar "illuminants" are allowed, if verified that the colorimetric measuring procedure is of the same sufficient accuracy, meaning that the quality of the simulation of D65 shall be assessed by the method

described in ISO 23603:2005(E)/CIE S 012/E:2004. The spectral distribution of the illuminant shall be in category BC (CIELAB) or better. The illumination shall be carried out at an angle 45 deg. to the normal and viewed along the normal (geometry 45/0).

93.4.2.3.2 Colour of the fluorescent material with retro-reflection:

93.4.2.3.2.1 For testing the colour of the fluorescent material, the material shall be illuminated by the CIE Standard Illuminant D65 (ISO 11664-2:2007(E)/CIE S 014-2/E:2006) and measured with a spectrophotometer in accordance with the provisions of publication CIE 15:2004, Recommendations on Colorimetry - second edition, either illuminated polychromatically or with a monochromator providing stepwise the CIE Standard Illuminant D 65 (ISO 11664-2:2007(E)/CIE S 014-2/E:2006). In the latter case, the stepwise resolution $\Delta\lambda$ shall be not larger than 10 nm.

Alternatively, similar "illuminants" are allowed, if verified that the colorimetric measuring procedure is of the same sufficient accuracy, meaning that the quality of the simulation of D65 shall be assessed by the method described in ISO 23603:2005(E)/CIE S 012/E:2004. The spectral distribution of the illuminant shall be in category BC (CIELAB) or better. The illumination shall be carried out circumferential at an angle 45 deg. to the normal and viewed along the normal (annular geometry 45/0) (circumferential/normal geometry).

93.4.3 Determination of the luminance factor:

93.4.3.1 For the determination of the luminance factor, the sample shall be tested

(a) For retro-reflective devices without fluorescence (day time colours) and fluorescent material without retro-reflection with the same method as described in paragraph 4.2.3.1.;

(b) For fluorescent material with retro-reflection with the same method as described in paragraph 93.4.2.3.2.

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93.4.3.1.1 By putting the luminance L of the sample into relation to the luminance L_o of a perfect diffuser whose luminance factor beta_o is known under identical conditions of illumination and observation; the luminance factor beta of the sample then results from the formula:

$$\beta = \frac{L}{L_o} \cdot \beta_o$$

93.4.3.1.2 When the colour of the fluorescent material has been colorimetrically determined in compliance with paragraph 93.4.2.3., from the ratio of the tristimulus value Y of the sample and the tristimulus value of the perfect diffuser Y_o in this case it is:

$$\beta = \frac{Y}{Y_o}$$

93.5 Specific technical requirements

93.5.1 Technical requirements concerning retro-reflectors of the Classes IA and IB (Symbols "IA" and "IB")

93.5.1.1 Every retro-reflector of the Classes IA and IB, when tested according to paragraph 93.5.1.7., shall meet:

- (a) The dimensions and shape requirements set forth in paragraph 93.7; and
- (b) The photometric and colorimetric requirements as specified in paragraphs 93.5.1.4. to 93.5.1.5.; and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.1.7., depending on the nature of the materials and construction of the retro-reflective devices.

93.5.1.2 The applicant shall submit ten samples for approval which shall be tested in the chronological order as indicated in

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paragraph 93.5.1.7.

93.5.1.3 Test procedure

93.5.1.3.1 After verification of the general specifications (paragraph 93.4.) and the specifications of shape and dimensions (paragraph 93.7), the ten samples shall be subjected to the heat resistance test described in paragraph 93.8 and at least one hour after this test examined as to their colorimetric characteristics and CIL in paragraph 93.5.1.4., for an angle of divergence of 20' and an illumination angle $V = H = 0$ deg. or if necessary, in the position defined in paragraph 93.5.1.4.

The two retro-reflective devices giving the minimum and maximum values shall then be fully tested as shown in paragraph 93.5.1.4. These two samples shall be kept by the laboratories for any further checks which may be found necessary.

The other four samples shall be divided into two groups of two:

First group: The two samples shall be subjected successively to the water penetration test (paragraph 93.9) and then, if this test is satisfactory, to the tests for resistance to fuels and lubricants (paragraph 93.11 and paragraph 93.12).

Second group: The two samples shall, if necessary, be subjected to the corrosion test in paragraph 93.13, and then to the abrasive-strength test of the rear face of the retro-reflective device paragraph 93.14.

93.5.1.3.2 After undergoing the tests referred to in the paragraph 93.5.1.3.1., the retro-reflective devices in each group must have:

93.5.1.3.2.1 A colour which satisfies the conditions laid down in paragraph 93.5.1.5.

93.5.1.3.2.2 A CIL which satisfies the conditions laid down in paragraph 93.5.1.4. The verification shall be performed only for an angle of divergence of 20' and an illumination angle of $V = H = 0$ deg. or, if necessary, in all positions

specified in paragraph 93.5.1.4.

93.5.1.4 Minimum values for the CIL values of retro-reflection

93.5.1.4.1 When applying for approval, the applicant shall specify one or more or a range of axis of reference, corresponding to the illumination angle $V = H = 0$ deg. in the table of coefficients of luminous intensity (CIL).

93.5.1.4.2 In the case where more than one or a range of different axis of reference are specified by the manufacturer, the photometric measurements shall be repeated making reference each time to a different axis of reference or to the extreme axis of reference of the range specified by the manufacturer.

93.5.1.4.3 For photometric measurements, only the illuminating surface defined by the planes contiguous to the outermost parts of the optical system of the retro-reflective device as indicated by the manufacturer and contained within a circle of 200 mm diameter for Class IA or IB shall be considered, and the illuminating surface itself shall be limited to 100 cm² though the surfaces of the retro-reflecting optical units need not necessarily attain this area. The manufacturer shall specify the perimeter of the area to be used.

93.5.1.4.4 Class IA and Class IB

93.5.1.4.4.1 When measured as described in paragraph 92.6.3, the CIL values for red retroreflective devices must be equal to or greater than those in Table 1, expressed in millicandelas per lux, for the angles of divergence and illumination shown.

Class	Angle of divergence alpha	Illumination angles (in degrees)			
		Vertical V	0 deg.	+/-10 deg.	+/-5 deg.
		Horizontal H	0 deg.	0 deg.	+/-20 deg.
IA, IB	20'		300	200	100
	1 deg. 30'		5	2.8	2.5

Table 1: Requirements for CIL values (Classes IA and IB) [mcd.lx^{-1}]

93.5.1.4.4.2 CIL values for amber retro-reflective devices in Class IA or IB must be at least equal to those in Table 1 multiplied by the coefficient 2.5.

93.5.1.4.4.3 CIL values for colourless retro-reflective devices in Class IA or IB must be at least equal to those in Table 1 multiplied by the coefficient 4.

93.5.1.4.5 However, in the case where a retro-reflective device of Class IA or Class IB, is intended to be installed with its H plane at a mounting height less than 750 mm above the ground, the CIL values are verified only up to an angle of 5 deg. downwards.

93.5.1.5 Colour of the reflected light of the device

93.5.1.5.1 The testing of the colour for retro-reflective device (night-time colour) shall be carried out according to the method described in paragraph 93.4.2.1.

93.5.1.5.2 The trichromatic coordinates of the reflected luminous flux must be within the limits for the night-time colours red, amber or white as specified in “The installation of lighting and light-signaling devices”.

93.5.1.6 Special specification (tests) / resistance to external agents

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Depending on the nature of the materials of which the retro-reflective devices and, in particular, their optical units, are made, the Type Approval Authorities may authorize laboratories to omit certain unnecessary tests, subject to the express reservation that such omission must be mentioned in test report. This is only applicable to tests described in paragraph 93.13. and. paragraph 93.14.

93.5.1.7 Chronological order of tests

Paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
-	General specifications: visual inspection	x	x	x	x	x	x	x	x	x	x
7	Shapes and dimensions: visual inspection	x	x	x	x	x	x	x	x	x	x
8	Heat: 48 h at 65° ± 2°C	x	x	x	x	x	x	x	x	x	x
	Visual inspection for distortion	x	x	x	x	x	x	x	x	x	x
5	Colorimetry: visual inspection	x	x	x	x	x	x	x	x	x	x
	Trichromatic coordinates in case of doubt		x								
6	Photometry: limited to 20' and V = H = 0°	x	x	x	x	x	x	x	x	x	x
6	Complete photometry			x	x						
9	Water: 10 min. in normal position							x	x		
	10 min. in inverted position							x	x		
	visual inspection							x	x		
5	Colorimetry: visual inspection							x	x		
	Trichromatic coordinates in case of doubt							x	x		
6	Photometry: limited to 20' and V = H = 0°							x	x		
11	Motor fuels: 5 min.							x	x		
	visual inspection							x	x		
12	Oils: 5 min.							x	x		
	visual inspection							x	x		

Paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt							x	x		
6	Photometry: limited to 20' and V = H = 0°							x	x		
13	Corrosion: 24 hours 2 hours interval 24 hours visual inspection					x	x				
14	Rear face: 1 min. visual inspection					x	x				
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt					x	x				
6	Photometry: limited to 20' and V = H = 0°					x	x				
4	Deposit of samples with authority			x	x						

Table 2: Chronological order of tests (Classes IA and IB)

93.5.2 Technical requirements concerning retro-reflectors of the Classes IIIA and IIIB (Symbols IIIA and IIIB)

93.5.2.1 Every retro-reflector of the Classes IIIA and IIIB, when tested according to paragraph 93.5.2.6., shall meet:

- (a) The dimensions and shape requirements set forth in paragraph 93.7.; and
- (b) The photometric and colorimetric requirements as specified in paragraphs 93.5.2.3.to 93.5.2.4.; and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.2.6., depending on the nature of the materials and construction of the retro-reflective devices

93.5.2.2 The applicant shall submit ten samples for approval which shall be tested in the chronological order as indicated in

paragraph 93.5.2.6.

93.5.2.2.1 After verification of the general specifications (paragraph 93.4) and the specifications of shape and dimensions (paragraph 93.7), the ten samples shall be subjected to the heat resistance test described in paragraph 93.8 and at least one hour after this test examined as to their colorimetric characteristics and CIL in paragraph 93.5.2.3., for an angle of divergence of 20' and an illumination angle $V = H = 0$ deg. or if necessary, in the position defined in paragraph 93.5.2.2.2.

The two retro-reflective devices giving the minimum and maximum values shall then be fully tested as shown in paragraph 93.5.2.4. These two samples shall be kept by the laboratories for any further checks which may be found necessary.

The other four samples shall be divided into two groups of two:

First group: The two samples shall be subjected successively to the water penetration test (paragraph 93.9) and then, if this test is satisfactory, to the tests for resistance to fuels and lubricants (paragraph 93.11 and paragraph 93.12).

Second group: The two samples shall, if necessary, be subjected to the corrosion test in paragraph 93.13, and then to the abrasive-strength test of the rear face of the retro-reflective device paragraph 93.14.

93.5.2.2.2 After undergoing the tests referred to in the paragraph 93.5.2.2.1., the retro-reflective devices in each group must have:

93.5.2.2.2.1 a colour which satisfies the conditions laid down in paragraph 93.5.2.4.;

93.5.2.2.2.2 a CIL which satisfies the conditions laid down in paragraph 93.5.2.3. The verification shall be performed only for an angle of divergence of 20' and an illumination angle of $V = H = 0$ deg. or, if necessary, in all positions specified in paragraph 93.5.2.3.

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93.5.2.3 Minimum values for the CIL values of retro-reflection

93.5.2.3.1 When measured as described in paragraph 93.6, the CIL values for red retro-reflective devices must be equal to or greater than those in Table 3, expressed in millicandelas per lux(mcd/lux), for the angles of divergence and illumination shown.

Class	Angle of divergence alpha	Illumination angles (in degrees)			
		Vertical V	0 deg.	+/-10 deg.	+/-5 deg.
		Horizontal H	0 deg.	0 deg.	+/-20 deg.
IIIA, IIIB	20'		450	200	150
	1 deg. 30'		12	8	8

Table 3: Requirements for CIL values (Classes IIIA and IIIB)

93.5.2.3.2 However, in the case where a retro-reflective device of Class IIIA or Class IIIB is intended to be installed with its H plane at a mounting height less than 750 mm above the ground, the CIL values are verified only up to an angle of 5 deg. downwards.

93.5.2.4 Colour of the reflected light of the device

93.5.2.4.1 The testing of the colour for retro-reflective device (night-time colour) shall be carried out according to the method described in paragraph 93.4.2.1.

93.5.2.4.2 The trichromatic coordinates of the reflected luminous flux must be within the limits for the night-time colour red as specified in “The installation of lighting and light-signaling devices”.

93.5.2.5 Special specification (tests) / resistance to external agents

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Depending on the nature of the materials of which the retro-reflective devices and, in particular, their optical units, are made, the Type Approval Authorities may authorize laboratories to omit certain unnecessary tests, subject to the express reservation that such omission must be mentioned in test report.

This is only applicable to tests described in paragraph 93.13 and paragraph 93.14.

93.5.2.6 Chronological order of tests

paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
-	General specifications: visual inspection	x	x	x	x	x	x	x	x	x	x
7	Shapes and dimensions: visual inspection	x	x	x	x	x	x	x	x	x	x
8	Heat: 48 h at 65° ± 2°C Visual inspection for distortion	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt	x	x x	x	x	x	x	x	x	x	x
6	Photometry: limited to 20' and V = H = 0°	x	x	x	x	x	x	x	x	x	x
6	Complete photometry			x	x						
9	Water: 10 min. in normal position 10 min. in inverted position visual inspection							x x x	x x x		

paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt							x	x		
6	Photometry: limited to 20' and V = H = 0°							x	x		
11	Motor fuels: 5 min. visual inspection							x	x		
12	Oils: 5 min. visual inspection							x	x		
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt							x	x		
6	Photometry: limited to 20' and V = H = 0°							x	x		
13	Corrosion: 24 hours 2 hours interval 24 hours visual inspection					x	x				
14	Rear face: 1 min. visual inspection					x	x				
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt					x	x				
6	Photometry: limited to 20' and V = H = 0°					x	x				
6	Deposit of samples with authority			x	x						

Table 4: Chronological order of tests (Classes IIIA and IIIB)

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93.5.3 Technical requirements concerning retro-reflectors of the Class IVA (Symbols "IVA")

93.5.3.1 Every retro-reflector of the Class IVA, when tested according to paragraph 93.5.3.7., shall meet:

- (a) The dimensions and shape requirements set forth in paragraph 93.7; and
- (b) The photometric and colorimetric requirements as specified in paragraphs 93.5.3.4. to 93.5.3.5.; and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.3.7., depending on the nature of the materials and construction of the retro-reflective devices.

93.5.3.2 The applicant shall submit ten samples for approval which shall be tested in the chronological order as indicated in paragraph 93.5.3.7.

93.5.3.3 Test procedure

93.5.3.3.1 After verification of the specifications in paragraph 93.4. and the specifications of shape and dimensions in paragraph 93.7, the ten samples shall be subjected to the heat resistance test in paragraph 93.8 and one hour minimum after this test examined as to their colorimetric characteristics and CIL in paragraph 93.5.3.4. for an angle of divergence of 20' and an illumination angle $V = H = 0$ deg.

The two retro-reflective devices giving the minimum and maximum values shall then be fully tested as shown in paragraph 93.5.3.4. These two samples shall be kept by the laboratories for any further checks which may be found necessary.

93.5.3.3.2 Four samples out of the remaining eight samples shall be selected at random and divided into two groups of two in each group.

First group:

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The two samples shall be subjected successively to the water-penetration resistance test in paragraph 93.9 and then, if this test is satisfactory, to the tests for resistance to fuels and lubricating oils in paragraph 93.11 and paragraph 93.12.

Second group:

The two samples shall, if relevant, be subjected to the corrosion test (paragraph 93.13), and then to the abrasive-strength test of the rear face of the retro-reflective device in paragraph 93.14, these two samples shall also be subjected to the impact test in paragraph 93.19.

93.5.3.3.3 After undergoing the tests referred to in the above paragraph, the retro-reflective devices in each group must have:

93.5.3.3.3.1 A colour which satisfies the conditions laid down in paragraph 93.4.2.1. This shall be verified by a qualitative method and, in case of doubt, confirmed by a quantitative method;

93.5.3.3.3.2 A CIL which satisfies the conditions laid down in paragraph 93.5.3.4. Verification shall be performed only for an angle of divergence of 20' and an illumination angle of $V = H = 0$ deg. or, if necessary, in the positions specified in paragraph 93.5.3.4.

93.5.3.3.4 The four remaining samples can be utilized, if necessary, for any other purpose. Every Retro-reflectors of the Classes IVA shall meet the requirements of the checks and tests described in paragraph 93.5.3.4.

93.5.3.4 Minimum values for the CIL values of retro-reflection

93.5.3.4.1 When measured as described in paragraph 93.6.3, for devices of Class IVA the CIL values must be equal to or greater than those in Table 5, expressed in millicandelas per lux, for the angles of divergence and illumination shown.

Colour	Angle of divergence alpha	Illumination angles (in degrees)						
		Vertical V	0	+/-10	0	0	0	0
		Horizontal H	0	0	+/-20	+/-30	+/-40	+/-50
White	20'		1,800	1,200	610	540	470	400
	1 deg. 30'		34	24	15	15	15	15
Amber	20'		1,125	750	380	335	290	250
	1 deg. 30'		21	15	10	10	10	10
Red	20'		450	300	150	135	115	100
	1 deg. 30'		9	6	4	4	4	4

Table 5: Requirements for CIL values (Class IVA) [mcd.lx-1]

93.5.3.4.2 However, in the case where a retro-reflective device of Class IVA is intended to be installed with its H plane at a mounting height less than 750 mm above the ground, the CIL values are verified only up to an angle of 5 deg. downwards.

93.5.3.5 Colour of the reflected light of the device

93.5.3.5.1 The testing of the colour for retro-reflective device (night-time colour) shall be carried out according to the method described in paragraph 93.4.2.1.

93.5.3.5.2 The trichromatic coordinates of the reflected luminous flux must be within the limits for the night-time colours red, amber or white as specified in “The installation of lighting and light-signaling devices”.

93.5.3.6 Special specification (tests) / resistance to external agents

Depending on the nature of the materials of which the retro-reflective devices and, in particular, their optical units, are made, the Type Approval Authorities may authorize laboratories to omit certain unnecessary tests, subject to the express reservation that such omission must be mentioned in test report. This is only applicable to tests described in paragraph

93.13 and paragraph 93.14.

93.5.3.7 Chronological order of tests for Class IVA

paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
-	General specifications: visual inspection	x	x	x	x	x	x	x	x	x	x
7	Shape and dimensions: visual inspection	x	x	x	x	x	x	x	x	x	x
8	Heat: 48 h at 65 °C ± 2°C Visual inspection for distortion	x x	x x	x x	x x	x x	x x	x x	x x	x x	x x
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt	x	x x	x	x	x	x	x	x	x	x
6	Photometry: limited to 20' and V = H = 0°	x	x	x	x	x	x	x	x	x	x
6	Complete photometry	x	x								
9	Water: 10 min. in normal position 10 min. in inverted position visual inspection			x x x	x x x						
11	Motor fuels: 5 min. visual inspection			x x	x x						
12	Oils: 5 min visual inspection			x x	x x						
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt			x x	x x						

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paragraph	Tests	Samples									
		a	b	c	d	e	f	g	h	i	j
6	Photometry: limited to 20' and V = H = 0°			x	x						
13	Corrosion: 24 hours 2 hours' interval 24 hours visual inspection					x	x				
14	Rear face: 1 min. visual inspection					x	x				
19	Impact visual inspection					x	x				
5	Colorimetry: visual inspection Trichromatic coordinates in case of doubt					x	x				
6	Photometry: limited to 20' and V = H = 0°					x	x				
6	Deposit of samples with Authority	x	x								

Table 6: Chronological order of tests (Class IVA)

93.5.4 Technical requirements concerning retro-reflective markings of the Classes C (Symbols "C")

93.5.4.1 Every retro-reflective marking of the Classes C, when tested according to paragraph 93.5.4.3., shall meet:

- (a) The dimensions and shape requirements set forth in paragraph 93.7; and
- (b) The photometric and colorimetric requirements as specified in paragraphs 93.5.4.4. to 93.5.4.5.; and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.4.6.

93.5.4.2 The applicant shall submit for approval:

93.5.4.2.1 Five test samples representing strips of retro-reflective marking materials have to be submitted to the test laboratory.

In the case of strips, at least a length of 3 meters shall be provided.

93.5.4.2.2 The test samples shall be representative of current production, manufactured in accordance with the recommendation of the manufacturer(s) of the retro-reflective marking materials.

93.5.4.3 Test procedure

93.5.4.3.1 After verification of the general specifications (paragraph 93.4.) and the specifications of shape and dimensions (paragraph 93.7), the samples shall be subjected to the heat resistance test described in paragraph 93.8, prior to the tests described in the paragraphs 93.5.4.4 and 93.5.4.5.

93.5.4.3.2 The photometric and colorimetric measurements may be made on five samples. The mean values should be taken.

93.5.4.3.3 For other tests, samples which have not undergone any testing should be used.

93.5.4.4 Minimum values for the coefficient of retro-reflection

Photometric specifications for retro-reflective markings of Classes C and F:

93.5.4.4.1 When measured as described in paragraphs 93.6, the coefficient of retro-reflection R' (cd/m²/lux) of the retro-reflective areas in new condition shall be at least as indicated in Table 7 for white, yellow and red materials.

Observation angle α [°]	Entrance Angle β [°]					
	β_1	0	0	0	0	0
$\alpha=0.33(20')$	β_2	5	20	30	40	60
Colour						
Yellow		300	--	130	75	10
White		450	--	200	95	16

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Red		120	60	30	10	--
-----	--	-----	----	----	----	----

Table 7: Minimum values for the Coefficient of Retro-reflection R'[cd·m⁻²·lx⁻¹]

93.5.4.5 Colour of the reflected light of the device

93.5.4.5.1 The testing of the colour for retro-reflective device (night-time colour) shall be carried out according to the method described in paragraph 93.4.2.1.

93.5.4.5.2 The trichromatic coordinates of the reflected luminous flux must be within the limits for the night-time colours red, amber or white as specified in “The installation of lighting and light-signaling devices”.

93.5.4.6 Special specification (tests) / resistance to external agents

93.5.4.6.1 Resistance to weathering

A specimen shall be subjected to a test as specified in paragraph 93.15.

93.5.4.6.2 Resistance to corrosion

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.13.

93.5.4.6.3 Resistance to fuels

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.11.

93.5.4.6.4 Resistance to heat

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.8.

93.5.4.6.5 Resistance to cleaning

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.16.

93.5.4.6.6 Resistance to penetration of water

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A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.9.

93.5.4.6.7 Bonding strength (in the case of adhesive materials)

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.17.

93.5.4.6.8 In case of the principal passing beam, one gas-discharge light source.

93.5.4.6.9 Flexing

For samples that are to be adhered to a flexible substrate, i.e. tarpaulin, the following shall apply:

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.18.

93.5.4.7 Chronological order of tests for Classes C

93.5.4.7.1 Five test samples representing either strips or planes of retro-reflective marking materials have to be submitted to the test laboratory. In the case of strips, at least a length of 3 meters shall be provided; in the case of planes, at least a surface of 500 mm x 500 mm shall be provided.

93.5.4.7.2 The test samples shall be representative of current production, manufactured in accordance with the recommendation of the manufacturer(s) of the retro-reflective marking materials.

93.5.4.7.3 After verification of the general specifications (paragraph 93.4) and the specifications of shape and dimensions (paragraph 93.7), the samples shall be subjected to the heat resistance test described in paragraph 93.8, prior to the tests described in paragraph 93.6.

93.5.4.7.4 The photometric and colorimetric measurements may be made on five samples. The mean values should be taken.

93.5.4.7.5 For other tests, samples which have not undergone any testing should be used.

93.5.5 Technical requirements concerning retro-reflective markings of the Classes D and E (Symbols "D" and "E")

93.5.5.1 Every retro-reflective marking of the Classes D and E shall meet the photometric requirements as specified in paragraphs

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93.5.5.3 to 93.5.5.5.

93.5.5.2 The applicant shall submit for approval:

93.5.5.2.1 Five test samples representing planes of retro-reflective marking materials have to be submitted to the test laboratory. In the case of planes, at least a surface of 500 mm x 500 mm shall be provided.

93.5.5.2.2 The test samples shall be representative of current production, manufactured in accordance with the recommendation of the manufacturer(s) of the retro-reflective marking materials.

93.5.5.3 Test procedure

Every retro-reflective marking of the Class D and E shall meet the requirements of the checks and tests described in paragraph 93.5.5.5.

93.5.5.4 Maximum values for the coefficient of retro-reflection

Observation angle α [°]		Entrance Angle β (°)				
		β_1	0	0	0	0
$\alpha = 0,33^\circ (20')$		β_2	5	30	40	60
		Any colour	class D	150	65	37
		class E	50	22	12	1

Table 8: Photometric specifications for distinctive markings or graphics of class D and class E: Maximum values for the Coefficient of Retro-reflection $R'[\text{cd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}]$

93.5.5.5 Colour of the reflected light of the device

93.5.5.5.1 Retro-reflective distinctive markings and/or graphics (classes D and E) may be of any colour.

93.5.5.6 Special specification (tests) / resistance to external agents

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93.5.5.6.1 Advertising, consisting of retro-reflective logos, distinctive markings or letters/ characters has to be decent.

It may consist of marking materials of class "D" if the total retro-reflective area is less than 2m²; if the total retro-reflective area is at least 2m² class "E" shall be used.

In the event of failure of an additional filament or LED light source or LED module, the headlamp shall continue to fulfil the requirements of the passing beam.

93.5.5.6.2 White retro-reflective marking materials intended as base or background in printing processes for fully coloured logos and markings of class "E" in use, without unprinted blank areas, may fulfil the requirements for class "D" materials and must be marked as class "D/E".

93.5.5.6.3 Depending on the nature of retro-reflective marking material, the Type Approval Authorities may authorize laboratories to omit certain unnecessary tests, provided that such omission is mentioned in test report.

93.5.6 Technical requirements concerning retro-reflective markings of the Class F and retroreflective marking plates of the Class 5

93.5.6.1 Every retro-reflective marking of the Class F shall meet the requirements of the checks and tests for:

- (a) Dimensions and shape set forth in paragraph 93.7; and
- (b) The photometric and colorimetric requirements as specified in paragraph 93.5.6.4 to 93.5.6.5; and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.5.6.

93.5.6.2 The applicant shall submit for approval:

93.5.6.2.1 Five test samples representing either strips or planes of retro-reflective marking materials to the test laboratory. In the case of strips, at least a length of 3 meters shall be provided; in the case of planes, at least a surface of 500 mm x 500 mm shall be provided.

93.5.6.2.2 The test samples shall be representative of current production, manufactured in accordance with the

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recommendation of the manufacturer(s) of the retro-reflective marking materials.

The samples shall be tested in the chronological order indicated in paragraph 93.5.6.4.

93.5.6.3 Test procedure

Every retro-reflective marking of the Class F and Class 5 shall meet the requirements of the checks and tests described in paragraphs 93.5.6.4 and 93.5.6.5.

93.5.6.4 Minimum values for the Coefficient of Retro-reflection Photometric specifications for retro-reflective markings of Class F

Observation angle α [°]	Entrance Angle β [°]					
	$\alpha=0.33(20')$	β_1	0	0	0	0
	β_2	5	20	30	40	60
Colour						
White		450	--	200	95	16
Red		120	60	30	10	--

Table 9: Minimum values for the Coefficient of Retro-reflection $R'[\text{cd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}]$

93.5.6.5 Colour of the reflected light of the device

93.5.6.5.1 The testing of the day-time colour for retro-reflective device shall be carried out according to the method described in paragraph 93.4.2.2

93.5.6.5.2 The trichromatic coordinates of the reflected luminous flux must be within the limits for the red and white colour as specified in “The installation of lighting and light-signaling devices”.

93.5.6.5.3 Luminance factor determined in accordance to paragraph 4.2.2.:

For red colour shall be ≤ 0.03 ,

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For white colour, it shall be ≤ 0.25 .

93.5.6.6 Special specification (tests) / resistance to external agents

93.5.6.6.1 Resistance to weathering

A specimen shall be subjected to a test as specified in paragraph 93.15.

93.5.6.6.2 Resistance to corrosion

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.13.

93.5.6.6.3 Resistance to fuels

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.11.

93.5.6.6.4 Resistance to heat

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.8.

93.5.6.6.5 Resistance to cleaning

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.16.

93.5.6.6.6 Resistance to penetration of water

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.9.

93.5.6.6.7 Bonding strength (in the case of adhesive materials)

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.17.

93.5.6.6.8 Flexing

For samples that are to be adhered to a flexible substrate, i.e. tarpaulin, the following shall apply:

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.18.

93.5.6.7 General requirements for light sources

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In the case of Plates:

A specimen of a complete plate shall be subjected to a test of rigidity of plates as specified in paragraph 93.20.

93.5.7 Technical requirements concerning retro-reflective markings plates of the Classes 1, 2,3 and 4

93.5.7.1 Retro-reflective devices of this paragraph must satisfy the conditions as to

- (a) Dimensions and shape set forth in paragraph 93.7, and
- (b) The photometric and colorimetric as specified in paragraphs 93.5.7.4 to 93.5.7.5 and
- (c) The physical and mechanical requirements set forth in paragraph 93.5.7.6.

93.5.7.2 The applicant shall submit for approval:

93.5.7.2.1 Two large chevron rear marking plates for trucks and tractors and two large rear marking plates for trailers and semi-trailers (or their equivalent in smaller plates) shall be supplied to the testing laboratory for the various tests to be conducted.

93.5.7.2.2 The test samples shall be representative of current production, fabricated in accordance with the recommendations of the manufacturer of the retro-reflective or retro-reflective/ fluorescent materials or devices.

The samples shall be tested in the chronological order indicated in paragraph 93.5.7.3.

93.5.7.3 Test procedure

Every retro-reflective marking Plate of the classes 1, 2, 3 and 4: shall meet the requirements of the checks and tests described in paragraph 93.7.

93.5.7.3.1 After verification of the general specifications (paragraph 93.4) and the specifications of shape and dimensions (paragraph 93.7) the samples shall be subjected to the heat resistance test described in paragraph 93.8 to this Regulation, prior to the colorimetric, photometric and environmental test.

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93.5.7.3.2 The photometric and colorimetric measurements may be made on the same sample.

93.5.7.3.3 For the other tests, samples which have not undergone any testing should be used.

93.5.7.4 Maximum values for the coefficient of retro-reflection

Photometric specifications for retro-reflective markings plates of the classes 1, 2, 3 and 4:

Devices of class 1 and class 2 shall fulfil the values in Table 10 for yellow only,

Devices of class 3 and class 4 those in Table 10 for yellow and red.

Observation angle α [']	Entrance angle β [°]				
	β_1	0°	0°	0°	0°
20'	β_2	5°	30°	40°	60°
Coefficient R' [cd·m ⁻² ·lx ⁻¹]	Colour: Yellow	300	180	75	10
	Colour: Red	10	7	4	-

Table 10: Minimum values for the Coefficient of Retro-reflection R' [cd·m⁻²·lx⁻¹]

93.5.7.4.1 The subtended angle at the sample shall not be larger than 80'.

93.5.7.5 Colour of the reflected light of the device

93.5.7.5.1 The testing of the colour for retro-reflective device (night-time colour) shall be carried out according to the method described in paragraph 93.4.2.1.

93.5.7.5.1.1 The trichromatic coordinates of the reflected luminous flux must be within the limits for the red and yellow colour as specified in “The installation of lighting and light-signaling devices”.

93.5.7.5.2 The testing of the colour for retro-reflective device (day-time colour) shall be carried out according to the method

described in paragraph 93.4.2.2.

93.5.7.5.2.1 The trichromatic coordinates of the reflected luminous flux must be within the limits for the red and yellow colour as specified in “The installation of lighting and light-signaling devices”.

93.5.7.5.2.2 Luminance factor beta determined in accordance to paragraph 93.4.2.3:

(a) For red colour shall be ≥ 0.03 .

(b) For yellow colour, it shall be ≥ 0.16 .

93.5.7.5.3 The testing of the colour for the fluorescent material shall be carried out according to the method described in paragraph 93.4.2.3.

93.5.7.5.3.1 The trichromatic coordinates of the reflected luminous flux must be within the limits for the colour as specified in “The installation of lighting and light-signaling devices”.

93.5.7.5.3.2 Luminance factor beta determined in accordance to paragraph 93.4.2.3.: for red colour shall be ≥ 0.3 .

93.5.7.5.4 Rear marking plates for heavy vehicles and trailers shall be composed of yellow retroreflective and red retro-reflective or yellow retro-reflective and red fluorescent materials or devices.

93.5.7.6 Special specification (tests) / resistance to external agents

93.5.7.6.1 Resistance to weathering

A specimen shall be subjected to a test as specified in paragraph 93.15.

93.5.7.6.2 Resistance to corrosion

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.13.

93.5.7.6.3 Resistance to fuels

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.11.

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93.5.7.6.4 Resistance to heat

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.8.

93.5.7.6.5 Resistance to cleaning

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.16.

93.5.7.6.6 Resistance to penetration of water

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.9.

93.5.7.6.7 Bonding strength (in the case of adhesive materials)

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.17.

93.5.7.6.8 Flexing

93.5.7.6.8.1 For samples that are to be adhered to a flexible substrate, i.e. tarpaulin, the following shall apply:

A specimen of the sample unit shall be subjected to a test as specified in paragraph 93.18.

93.5.7.6.8.2 In the case of Plates:

A specimen of a complete plate shall be subjected to a test of rigidity of plates as specified in paragraph 93.20.

93.5.7.7 Chronological order of tests for Classes 1, 2, 3 and 4

93.5.7.7.1 Two large chevron rear marking plates for trucks and tractors and two large rear marking plates for trailers and semi-trailers (or their equivalent in smaller plates) shall be supplied to the testing laboratory for the various tests to be conducted.

93.5.7.7.2 The test samples shall be representative of current production, fabricated in accordance with the recommendations of the manufacturer of the retro-reflective or retro-reflective/ fluorescent materials or devices.

93.5.7.7.3 After verification of the general specifications (paragraph 93.4) and the specifications of shape and dimensions

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(paragraph 93.7) the samples shall be subjected to the heat resistance test described in paragraph 93.8, prior to the tests described in paragraphs 93.4.2 and 93.5.7.4 and 93.10.

93.5.7.7.4 The photometric and colorimetric measurements may be made on the same sample.

93.5.7.7.5 For the other tests, samples which have not undergone any testing should be used.

93.6 Photometric measurements of retro-reflective devices and marking materials

93.6.1 Test procedures

93.6.1.1 When the CIL of a retro-reflective device is measured for an angle beta of $V = H = 0$ deg., it shall be ascertained whether any mirror effect is produced by slightly turning the device. If there is any such effect, a reading shall be taken with an angle beta of $V = +/- 5$ deg., $H = 0$ deg. The position adopted shall be that corresponding to the minimum CIL for one of these positions.

93.6.1.2 With an illumination angle β of $V = H = 0$ deg., or the angle specified in paragraph 93.5 of this Regulation, and an angle of divergence of $20'$, retro-reflective devices which are not marked "TOP" shall be rotated about their axes of reference to the position of minimum CIL, which must conform to the value specified in paragraph 93.5 of this Regulation. When the CIL is measured for the other angles of illumination and divergence, the retro-reflective device shall be placed in the position corresponding to this value of ϵ . If the specified values are not attained, the device may be rotated about its axis of reference $+/- 5$ deg. from that position.

93.6.1.3 With an illumination angle β of $V = H = 0$ deg., or the angle specified in paragraph 93.4. of this Regulation, and an angle of divergence of $20'$, retro-reflective devices marked "TOP" shall be rotated about their axes $+/- 5$ deg. The CIL must not fall below the prescribed value in any position assumed by the device during this rotation.

93.6.1.4 If for the direction $V = H = 0$ deg., and for $\epsilon = 0$ deg. the CIL exceeds the specified value by 50 per cent or more, all

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measurements for all angles of illumination and divergence shall be made for $\epsilon = 0$ deg.

93.6.2 Definitions

The definitions are explained by Figures 1 to 5.

93.6.3 Dimensional and physical specifications for the photometry of retro-reflective devices

93.6.3.1 The CIE-angular system as shown in Figure 1 shall be used. An adequate support (goniometer) is demonstrated in Figure 2.

93.6.3.2 For testing the retro-reflection the retro-reflective devices shall be illuminated with a CIE Standard Illuminant A (ISO 11664-2:2007(E)/CIE S 014-2/E:2006) and measured as described in paragraph 93.6.

93.6.3.3 The measuring geometry is described in Figure 1 and the following limits are set up:

Angular diameter of the source - $\delta \leq 10'$

Angular diameter of the measuring device - $\gamma \leq 10'$

Angular diameter of the illuminated area - $\eta \leq 80'$

93.6.3.4 During photometric measurements, stray reflections should be avoided by appropriate masking.

93.6.3.5 The measuring distance shall be chosen in such an order that at least the limits for the angles δ , γ and η given in Figure A4-IV are respected, but not lower than 10 m or its optical equivalent. The retro-reflection values shall be determined by means of a measuring geometry as described above with the retro-reflecting device set up to a distance of at least 10m forward of the centre of reference of each retro-reflecting device perpendicular to the measurement axis from the origin of the gonio(photo)meter system.

93.6.3.6 The illuminance at the retro-reflective device

The illuminance over the useful area of the retro-reflective device, measured perpendicular to the incident light shall be

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sufficiently uniform. A check on this condition requires a measuring element, the sensitive area of which is not greater than one-tenth of the area to be examined. The variation in the value of the illuminance shall then comply with the condition:

93.6.3.7 The colour temperature and the spectral distribution of the source

The source used for illuminating the retro-reflective device shall as faithfully as possible represent the CIE Illuminant A, both as regards colour temperature and spectral power distribution.

93.6.3.8 The photometer head (measuring element)

93.6.3.8.1 The photometer head shall be corrected to the spectral luminous efficiency for the CIE standard photometric observer in photopic vision.

93.6.3.8.2 The device shall not show a perceptible change in local sensitivity within the area of its aperture; otherwise suitable provisions shall be added, e.g. the application of a diffusing window at a certain distance in front of the sensitive surface.

93.6.3.8.3 Experience has shown that non-linearity of photometer heads may be a problem with the very small light quantities which are the rule in the photometry of retro-reflective devices. A check at comparable illuminance levels on the photometer head is recommended.

93.6.3.9 The influence of a regular reflection

The amount and distribution of the regular reflection from the surface of the retro-reflector depends on the flatness and the gloss of the surface. In general, regular reflection is best avoided when the reference axis is placed so that the regular reflection is directed on the opposite side of the source from the photometer head (for example with $\beta_1 = -5$ deg.).

93.6.4 Measurement precautions in the photometry of retro-reflection

93.6.4.1 Residual and stray light

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93.6.4.1.1 Since very low light levels are to be measured special precautions are needed to minimize errors due to stray light.

The background to the sample and the framework of the sample holder should be matt black and the field of view of the photometer head and the spread of light from both the sample and the source should each be restricted as much as possible.

93.6.4.1.2 Reflections from the floor and walls which occur over the relatively long test distances used shall be screened from both the sample and the photometer head by baffles. The importance of looking from the photometer head to check for sources of stray light cannot be over emphasized.

93.6.4.1.3 A valuable aid to reducing the amount of stray light in the laboratory is to use a slide projector type of optical system for the light source. With this, an iris diaphragm or suitable sized apertures may be used in the optical system to restrict the illuminated area at the sample to the minimum size needed to provide uniform illuminance over the sample.

93.6.4.1.4 Residual stray light should always be allowed for by measuring it when the sample is covered by an opaque matt black surface, zigzag folded black paper of the same size and shape or a specular black surface suitably oriented with a light trap. This value should be subtracted from that measured on the retro-reflective device.

93.6.4.2 Stability of the apparatus

93.6.4.2.1 The light source and photometer head should remain stable throughout the period of the test. Since the sensitivity and the adaptation to the $V(\lambda)$ function of most photometer heads change with temperature, the laboratory ambient temperature should not vary significantly during this period. Sufficient time should always be allowed for the apparatus to stabilize before commencing measurements.

93.6.4.2.2 The power supply to the light source should be adequately stabilized so that the luminous intensity of the lamp can be maintained throughout the test to within the required accuracy for the work.

93.6.4.2.3 A useful check on the overall stability of the reflex photometer during a series of tests is to make periodic measurements of CIL values of a stable reference standard.

93.6.4.2.4 Another technique is to incorporate in the apparatus an auxiliary detector to check or monitor the output of the light source. Although the output from the auxiliary detector can be checked for any change in reading, a useful refinement is to use the output to alter electronically the sensitivity of the main reflex photometer head and compensate automatically for changes in the light output of the source.

93.6.4.3 Description of Goniometer

A goniometer as defined in paragraph 93.2.3 of this Regulation, which can be used in making retro-reflection measurements in the CIE geometry is illustrated in Figure 5. In this illustration, the photometer head (O) is arbitrarily shown to be vertically above the source (I). The first axis is shown to be fixed and horizontal and is situated perpendicular to the observation half-plane. Any arrangement of the components which is equivalent to the one shown can be used.

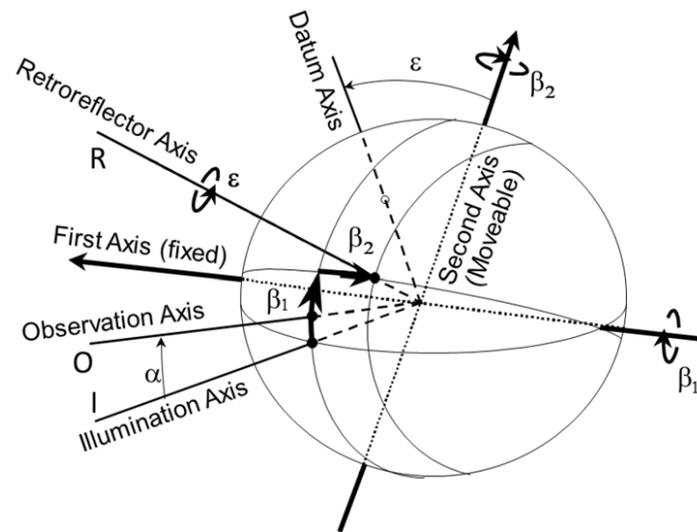
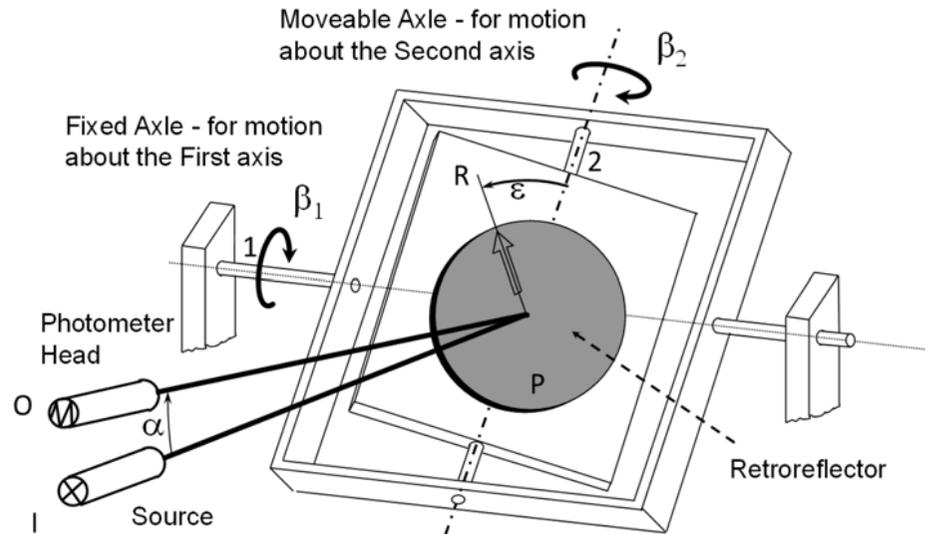


Figure 1 shows the CIE angular system for specifying and measuring retro-reflective device and marking materials. The first axis is perpendicular to the plane containing the observation axis and the illumination axis.

The second axis is perpendicular both to the first axis and to the reference axis.

Figure 1: The CIE co-ordinate system



1: First Axis

2: Second Axis

I: Illumination Axis

O: Observation Axis

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R: Reference Axis

P: Retro-reflective material

α : Observation angle

β_1, β_2 : Entrance angles

ε : Rotation angle

Figure 2 represents a Goniometer mechanism embodying the CIE angular system for specifying and measuring retro-reflective device and marking materials. All axes, angles, and directions of rotation are shown positive.

Notes:

- (a) The principle fixed axis is the illumination axis;
- (b) The first axis is fixed perpendicular to the plane containing the observation and illumination axis;
- (c) The reference axis is fixed in the retro-reflective device and moveable with β_1 and β_2 .

Figure 2: Goniometer mechanism embodying the CIE angular system

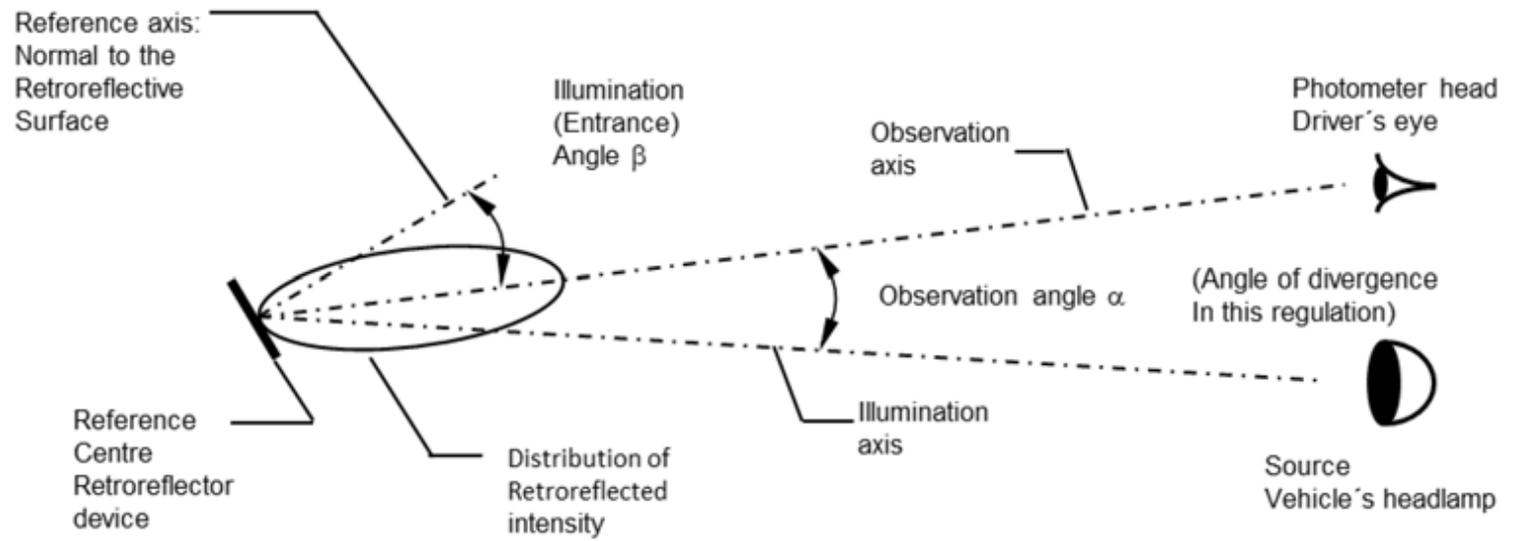
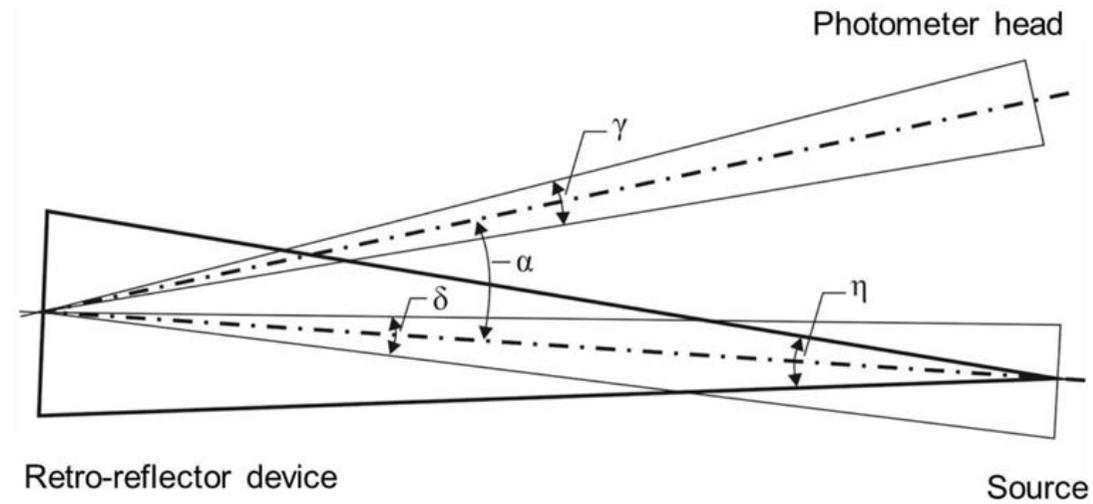


Figure 3: Distribution of retro-reflected light at retro-reflector



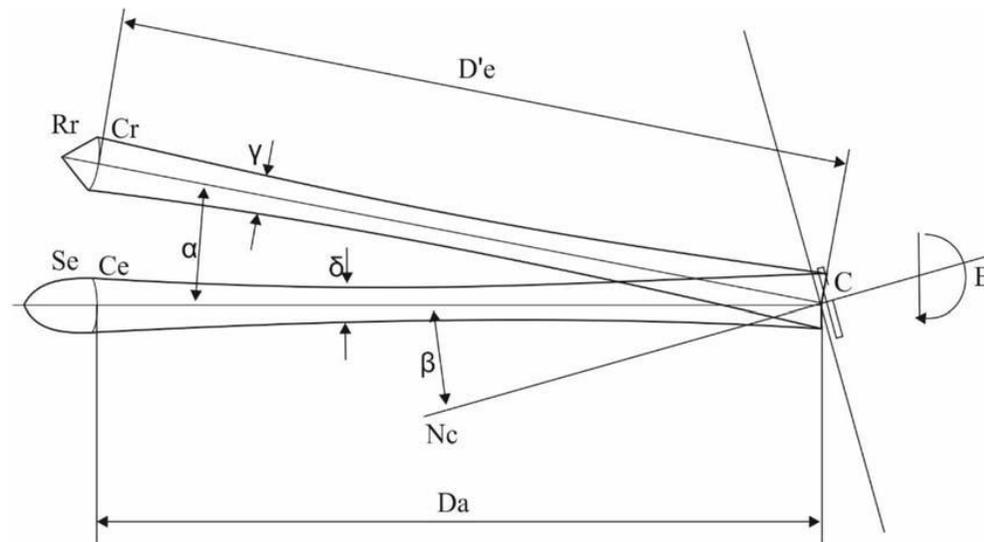
For the purpose of this Regulation, the following limits are set up:

$$\delta \leq 10'$$

$$\gamma \leq 10'$$

$$\eta \leq 80'$$

Figure 4: Measuring geometry for the measurement of a retro-reflective device



Symbols and units

A = Area of the illuminating surface of the retro-reflective device (cm²)

C = Centre of reference

NC = Axis of reference

Rr = Receiver, observer or measuring device

Cr = Centre of receiver

\varnothing_r

= Diameter of receiver Rr if circular (cm)

Se = Source of illumination

Cs = Centre of source of illumination

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\varnothing_s

= Diameter of source of illumination (cm)

D_e = Distance from centre C_s to centre C (m)

$D'e$ = Distance from centre C_r to centre C (m)

Note: In general, D_e and $D'e$ are very nearly the same and under normal conditions of observation it may be assumed that $D_e = D'e$.

D = Observation distance from and from beyond which the illuminating surface appears to be continuous
 α = Angle of divergence

β = Illumination angle.

γ = Angular diameter of the measuring device R_r as seen from point C

δ = Angular diameter of the source S_e as seen from point C

ϵ = Angle of rotation. This angle is positive when the rotation is clockwise as seen when looking towards the illuminating surface. If the retro-reflective device is marked "TOP", the position thus indicated is taken as the origin.

E = Illumination of the retro-reflective device (lux)

CIL = Coefficient of luminous intensity (millicandelas/lux)

Angles are expressed in degrees and minutes.

Figure 5: Arrangement of the test equipment for retro-reflective devices of Classes IA, IB, IIIA, IIIB, IVA

93.7 Specifications of shape and dimensions

93.7.1 Shape and dimensions of retro-reflective devices in Class IA or IB

93.7.1.1 The shape of the illuminating surfaces must be simple, and not easily confused at normal observation distances, with a

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letter, a digit or a triangle.

93.7.1.2 A shape resembling the letters or digits of simple form O, I, U or 8 is permissible.

93.7.2 Shape and dimensions of retro-reflective devices in Classes IIIA and IIIB

93.7.2.1 The illuminating surfaces of retro-reflective devices in Classes IIIA and IIIB must have the shape of an equilateral triangle.

If the word "TOP" is inscribed in one corner, the apex of that corner must be directed upwards.

93.7.2.2 The illuminating surface may or may not have at its centre a triangular, non-retroreflecting area, with sides parallel to those of the outer triangle.

93.7.2.3 The illuminating surface may or may not be continuous. In any case, the shortest distance between two adjacent retro-reflecting optical units must not exceed 15 mm.

93.7.2.4 The illuminating surface of a retro-reflective device shall be considered to be continuous if the edges of the illuminating surfaces of adjacent separate optical units are parallel and if the said optical units are evenly distributed over the whole solid surface of the triangle.

93.7.2.5 If the illuminated surface is not continuous, the number of separate retro-reflecting optical units including the corner units shall not be less than four on each side of the triangle.

93.7.2.5.1 The separate retro-reflecting optical units shall not be replaceable unless they consist of approved retro-reflective devices in Class IA.

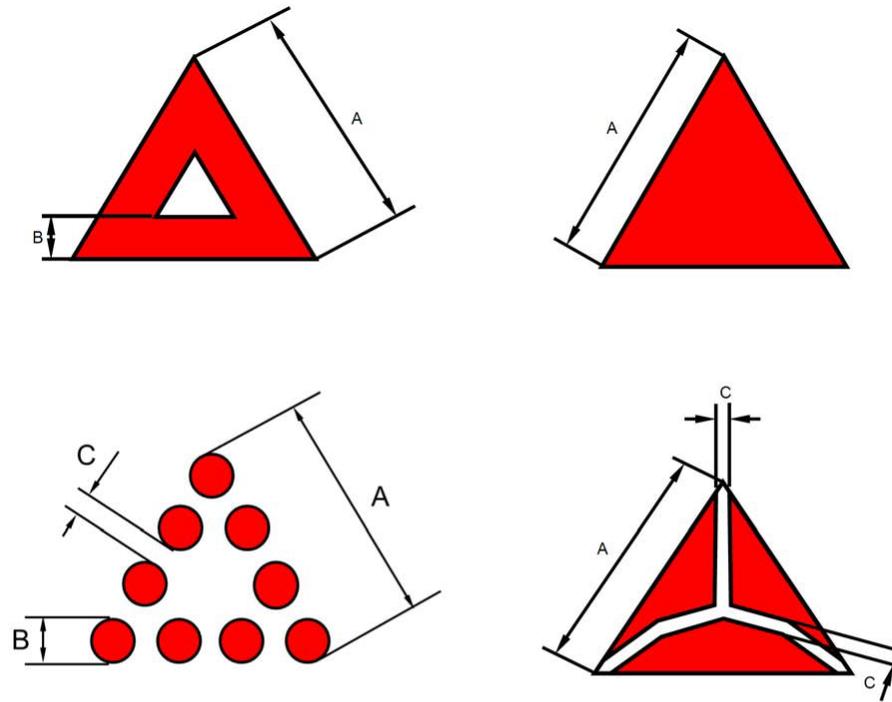
93.7.2.6 The outside edges of the illuminating surfaces of triangular retro-reflective devices in Classes IIIA and IIIB shall be between 150 and 200 mm long. In the case of devices of hollow-triangle type, the width of the sides, measured at right angles to the latter, shall be equal to at least 20 per cent of the effective length between the extremities of the illuminating surface.

93.7.3 Shape and dimensions of retro-reflective devices in Class IVA

93.7.3.1 The shape of the light emitting surfaces must be simple and not easily confused at normal observation distances with a letter, a digit or a triangle. However, a shape resembling the letters and digits of simple form, O, I, U and 8 is permissible.

93.7.3.2 The light emitting surface of the retro-reflective device must be at least 25 cm².

93.7.3.3 Compliance with the above specifications shall be verified by visual inspection.



$150 \text{ mm} \leq A \leq 200 \text{ mm}$ $B \geq \frac{A}{5}$ $C \leq 15 \text{ mm}$

Note: These sketches are for illustration purposes only.

Figure 6: Retro-reflectors for trailers - Classes IIIA and IIIB

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93.7.4 Shape and dimensions of retro-reflective side and rear marking with strips

93.7.4.1 General

The markings shall be made of strips of retro-reflective material.

93.7.4.2 Dimensions

93.7.4.2.1 The width of a side and/or rear marking material shall be 50 mm +10/-0 mm.

93.7.4.2.2 The minimum length of an element of a retro-reflective marking material shall be such that at least one approval mark is visible.

93.7.5 Side, rear and/or front marking with strips (Class F) retro-reflective markings plates of the Class 5

93.7.5.1 General

The markings shall be made of strips of retro-reflective material.

93.7.5.2 Dimensions

93.7.5.2.1 Class F and Class 5 retro-reflective materials shall consist of red and white diagonal stripes downwards at 45 deg. as shown in Figures 7, 8 and 9 respectively. The basic standard area is a square of 141 mm +/- 1 mm in length subdivided diagonally into a white half and red half, which represents one standard area as shown in Figure 7.

93.7.5.2.2 The minimum length of an element of a retro-reflective marking material shall incorporate a minimum of 9 standard areas as described in paragraph 93.7.5.2.1. on large vehicles with available mounting space, but may be reduced to a minimum of 4 standard areas on vehicles with limited mounting space.

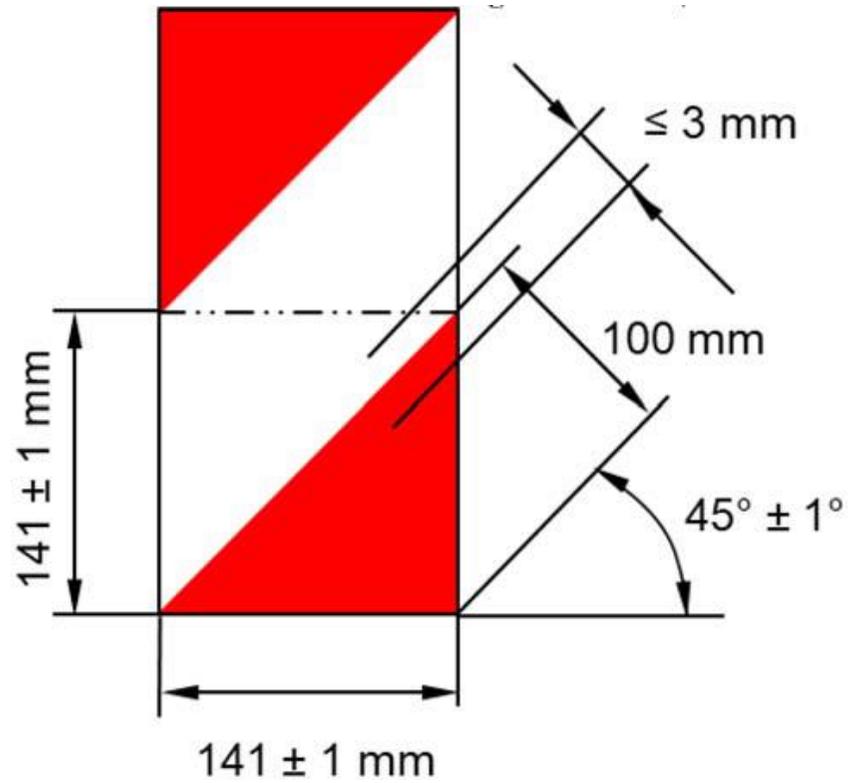


Figure 7: Retro-reflective material marking of Class F (Standard Element)

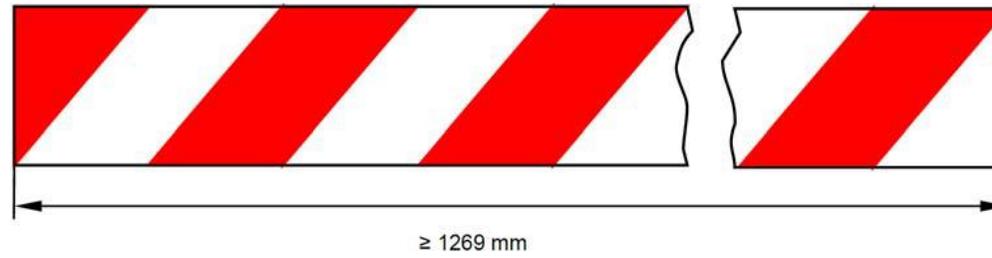


Figure 8: Retro-reflective material marking of Class F

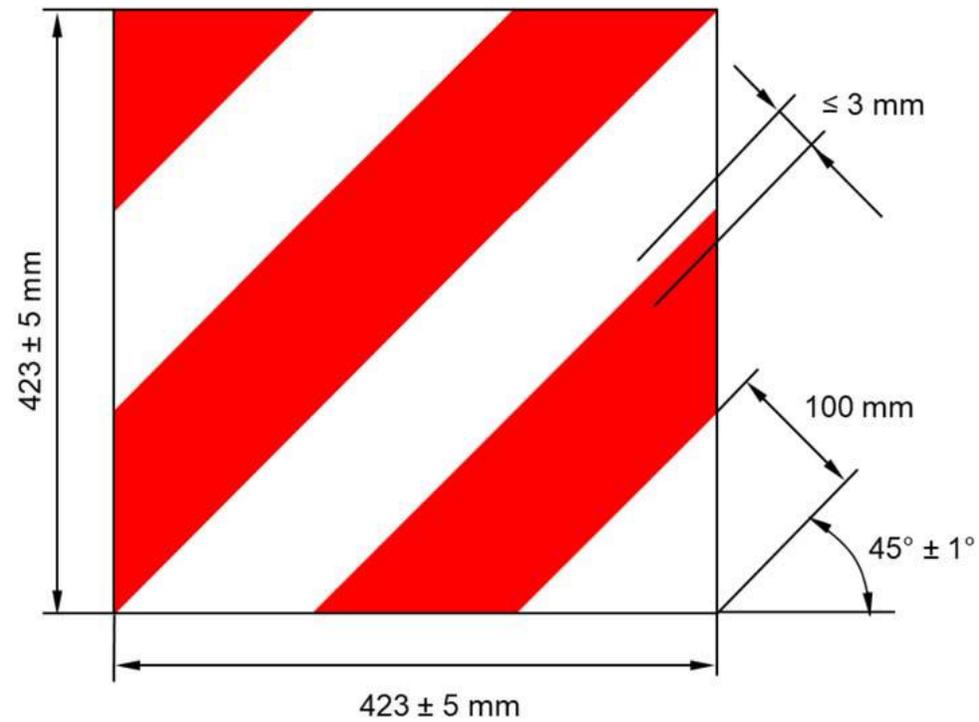


Figure 9: Retro-reflective material marking of Class 5

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93.7.6 Shape and dimensions of retro-reflective/fluorescent rear marking plate(s)

93.7.6.1 Shape

The plates shall be rectangular in shape for mounting at the rear of vehicles.

93.7.6.2 Pattern

For mounting on trailers and semi-trailers, the plates shall have a yellow retro-reflective background with a red fluorescent or retro-reflective border; For mounting on non-articulated vehicles (tractors or trucks), the plates shall be of the chevron type with alternate, oblique stripes of yellow retro-reflective and red fluorescent or retro-reflective materials or devices.

93.7.6.3 Dimensions

The minimum total summarized length of a set of rear marking plates consisting only of one, two or four marking plates with retro-reflective and fluorescent materials shall be 1,130 mm, the maximum total length shall be 2,300 mm.

93.7.6.3.1 The width of a rear marking plate shall be:

For trucks and tractors: 140 +/- 10 mm.

For trailers and semi-trailers:

$200 \begin{matrix} +30 \\ -5 \end{matrix} \text{ mm}$

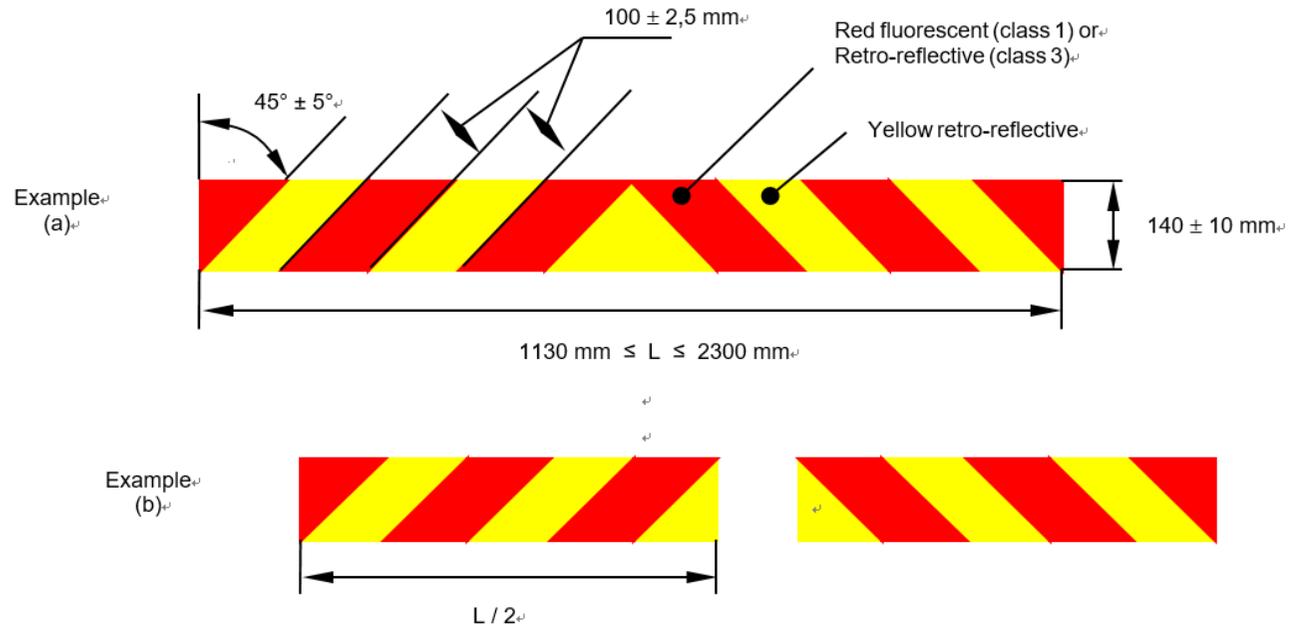
93.7.6.3.2 The length of each rear marking plate in a set consisting of two plates for trucks and tractors, as illustrated in Figures 10 and 11, may be reduced, to a minimum of 130 mm, provided that the width is increased such that the area of each marking is at least 735 cm², does not exceed 1,725 cm² and the marking plates are rectangular.

93.7.6.3.3 The width of the red fluorescent border of the rear marking plates for trailers and semitrailers shall be 40 mm +/- 1 mm.

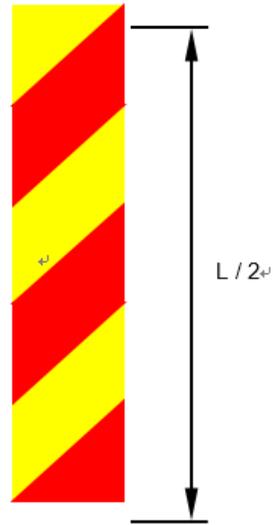
93.7.6.3.4 The slope of the oblique stripes of the chevron band shall be $45^\circ \pm 5^\circ$. The width of the stripes shall be $100 \text{ mm} \pm 2.5 \text{ mm}$.

Prescribed shapes, patterns and dimensional features are illustrated in Figure 10.

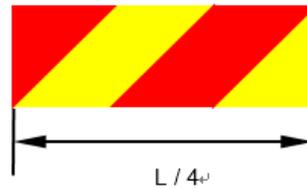
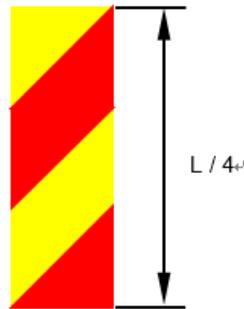
93.7.6.3.5 Rear marking plates supplied in sets shall form matching pairs.



Example (c)

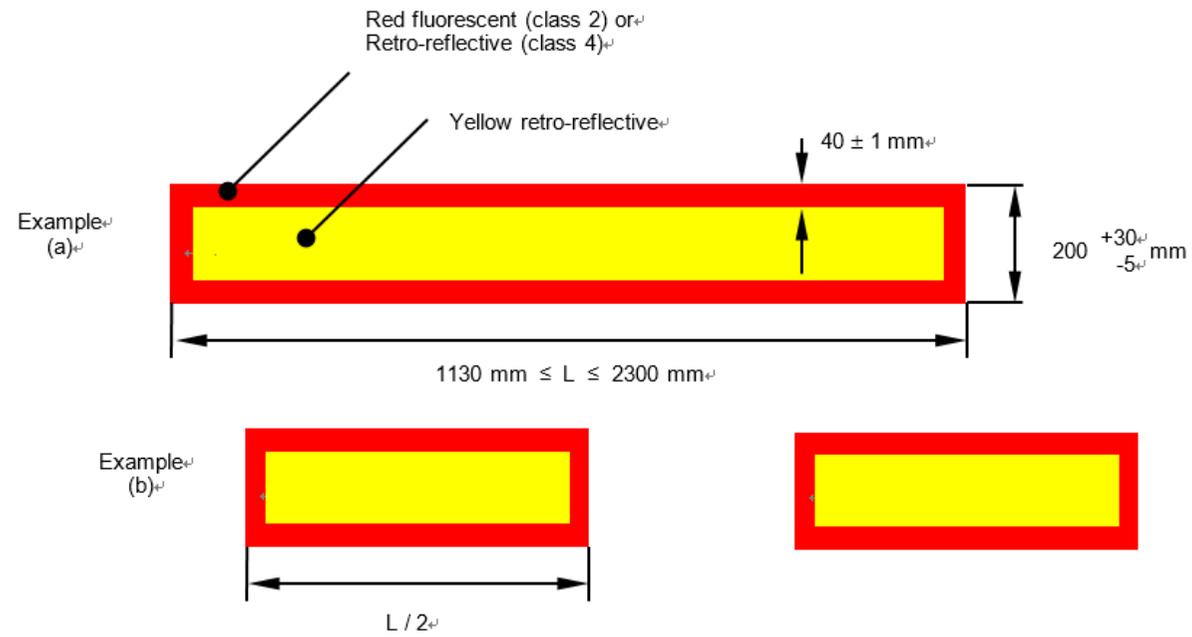


Example (d)



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Figure 10: Rear Marking Plates (Class 1 and Class 3)



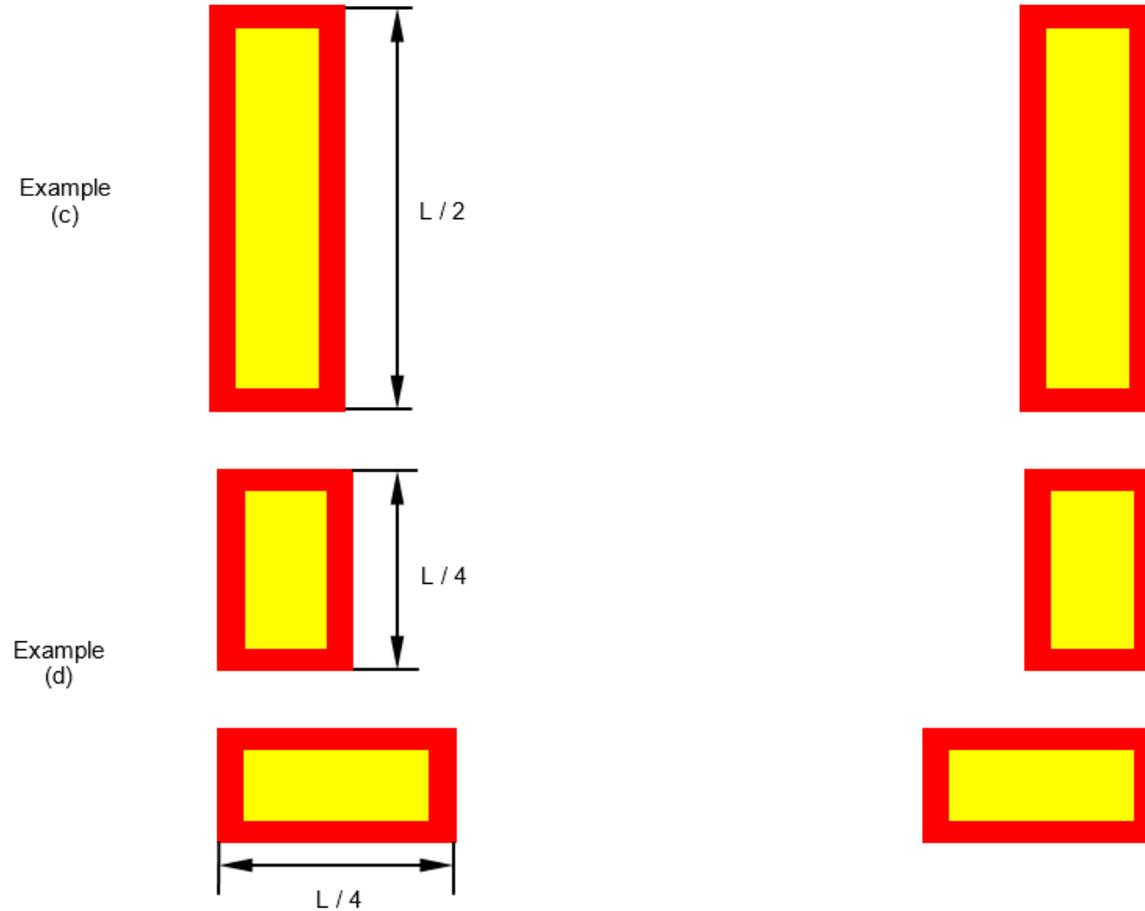


Figure 11: Rear marking Plates (Class 2 and Class 4)

93.8 Resistance to heat

93.8.1 Test procedure in the case of moulded plastics reflectors of retro-reflecting devices as Classes IA, IB, IIIA, IIIB, IVA, Marking

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plates of Classes 1, 2, 3, 4, 5, and Advance warning triangle of type 1: The retro-reflective device shall be kept for 48 consecutive hours in a dry atmosphere at a temperature of 65 deg. C +/- 2 deg. C after which the sample shall be allowed to cool for 1 hour at 23 deg. C +/- 2 deg. C.

93.8.2 Test procedure in the case of use of flexible materials for Classes C, F, 1, 2, 3, 4, 5 and Advance warning triangle of type 2: A section of a sample unit not less than 300 mm long shall be kept for 12 hours in a dry atmosphere at a temperature of 65 deg. C +/- 2 deg. C, after which the sample shall be allowed to cool for 1 hour at 23 deg. C +/- 2 deg. C. It shall then be kept for 12 hours at a temperature of - 20 deg. C +/- 2 deg. C.

The sample shall be examined after a recovery time of 4 hours under normal laboratory conditions.

93.8.3 After this test, no cracking or appreciable distortion of the retro-reflective device and, in particular, of its optical component must be visible.

93.9 Resistance to water penetration for retro-reflective devices

93.9.1 Test for retro-reflectors and retro-reflective markings

93.9.1.1 Retro-reflective devices whether part of a lamp or not, or a sample unit of retroreflective marking, shall be stripped of all removable parts and immersed for 10 minutes in water at a temperature of 50 deg. C +/- 5 deg. C, the highest point of the upper part of the illuminating surface being 20 mm below the surface of the water.

93.9.1.2 No water shall penetrate to the reflecting surface of the retro-reflecting optical unit. If visual inspection clearly reveals the presence of water, the device shall not be considered to have passed the test.

93.9.1.3 If visual inspection does not reveal the presence of water or in case of doubt:

93.9.1.3.1 In the case of retro-reflectors, the CIL shall be measured by the method described in paragraph 92.6, the retro-reflective device being first lightly shaken to remove excess water from the outside.

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93.9.1.3.2 In the case of a sample unit of retro-reflective marking the coefficient of retro-reflection R' shall be measured in paragraph 92.6, the sample unit being first lightly shaken to remove excess water from the outside.

93.9.2 Test for marking plates

93.9.2.1 Resistance to water

A section of a sample unit not less than 300 mm long shall be immersed in distilled water at a temperature of 23 +/- 5 deg. C for a period of 18 hours; it shall then be left to dry for 24 hours under normal laboratory conditions. After completion of the test, the section shall be examined. No part inside 10 mm from the cut edge shall show evidence of deterioration which would reduce the effectiveness of the plate.

93.10 Alternative test procedures of resistance to water penetration for retro-reflective devices of the Classes IB and IIIB

93.10.1 As an alternative, at the request of the manufacturer, the following tests (moisture and dust test) may be applied.

93.10.2 Moisture test

The test evaluates the ability of the sample device to resist moisture penetration from a water spray and determines the drainage capability of those devices with drain holes or other exposed openings in the device.

93.10.2.1 Water spray test equipment

A water spray cabinet with the following characteristics shall be used:

93.10.2.1.1 Cabinet

The cabinet shall be equipped with a nozzle(s) which provides a solid cone water spray of sufficient angle to completely cover the sample device. The centreline of the nozzle(s) shall be directed downward at an angle of 45 deg. +/- 5 deg. to the vertical axis of a rotating test platform.

93.10.2.1.2 Rotating test platform

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The rotating test platform shall have a minimum diameter of 140 mm and rotate about a vertical axis in the centre of the cabinet.

93.10.2.1.3 Precipitation rate

The precipitation rate of the water spray at the device shall be 2.5 (+1.6/-0) mm/min as measured with a vertical cylindrical collector centred on the vertical axis of the rotating test platform. The height of the collector shall be 100 mm and the inside diameter shall be a minimum of 140 mm.

93.10.2.2 Water spray test procedure

A sample device mounted on a test fixture, with initial CIL measured and recorded shall be subjected to a water spray as follows:

93.10.2.2.1 Device openings

All drain holes and other openings shall remain open. Drain wicks, when used, shall be tested in the device.

93.10.2.2.2 Rotational speed

The device shall be rotated about its vertical axis at a rate of 4.0 +/- 0.5 min.

93.10.2.2.3 If the retro-reflector is reciprocally incorporated or grouped with signalling or lighting functions, these functions shall be operated at design voltage according to a cycle of 5 min ON (in flashing mode, where appropriate), 55 min OFF.

93.10.2.2.4 Test duration

The water spray test shall last 12 hours (12 cycles of 5/55 min).

93.10.2.2.5 The device is robust enough to withstand 50,000 operations under normal conditions of use. In order to verify compliance with this requirement, the Technical Service responsible for approval tests may:

93.10.2.2.6 Sample evaluation

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Upon completion of the drain period. The interior of the device shall be observed for moisture accumulation. No standing pool of water shall be allowed to be formed, or which can be formed by tapping or tilting the device. The CIL shall be measured according to the method specified in paragraph 93.6 after having dried the exterior of the device with a dry cotton cloth.

93.10.2.3 Dust exposure test

This test evaluates the ability of the sample device to resist dust penetration which could significantly affect the photometric output of the retro-reflector.

93.10.2.3.1 Dust exposure test equipment

The following equipment shall be used to test for dust exposure:

93.10.2.3.2 Dust exposure test chamber

The interior of the test chamber shall be cubical in shape in size 0.9 to 1.5 m per side. The bottom may be "hopper shaped" to aid in collecting the dust. The internal chamber volume, not including a "hopper shaped" bottom shall be 2 m³ maximum and shall be charged with 3 to 5 kg of the test dust. The chamber shall have the capability of agitating the test dust by means of compressed air or blower fans in such a way that the dust is diffused throughout the chamber.

93.10.2.3.3 The dust

The test dust used shall be fine powdered cement in accordance with standard ASTM C 150-84.

93.10.2.3.4 Dust exposure test procedure

A sample device, mounted on a test fixture, with the initial CIL measured and recorded, shall be exposed to dust as follows:

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93.10.2.3.5 Device openings

All drain holes and other openings shall remain open. Drain wicks, when used, shall be tested in the device.

93.10.2.3.6 Dust exposure

The mounted device shall be placed in the dust chamber no closer than 150 mm from a wall. Devices with a length exceeding 600 mm shall be horizontally centred in the test chamber. The test dust shall be agitated as completely as possible by compressed air or blower(s) at intervals of 15 min for a period of 2 to 15 s for the duration of 5 hours. The dust shall be allowed to settle between the agitation periods.

93.10.2.3.7 Measured sample evaluation

Upon completion of the dust exposure test, the exterior of the device shall be cleaned and dried with a dry cotton cloth and the CIL measured according to the method specified in paragraph 93.6.

93.11 Resistance to fuels

93.11.1 A test mixture of 70 vol. per cent of n-heptane and 30 vol. per cent of toluol shall be applied for either:

93.11.1.1 A retro-reflective device:

- (a) The outer surface of the retro-reflective device and, in particular, of the illuminating surface, shall be lightly wiped with a cotton cloth soaked in the test mixture.
- (b) After about five minutes, the surface shall be inspected visually. It must not show any apparent surface changes, except that slight surface cracks will not be objected to.

or

93.11.1.2 A sample unit of retro-reflective marking;

- (a) A section of a sample unit not less than 300 mm long shall be immersed in the test mixture for one minute.

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(b)After removal, the surface shall be wiped dry with a soft cloth and shall not show any visible change which would reduce its effective performance.

93.12 Resistance to lubricating oils

93.12.1 Test procedure in the case of moulded plastics reflectors as Classes IA, IB, IIIA, IIIB, IVA

93.12.1.1 The outer surface of the retro-reflective device and, in particular, the illuminating surface, shall be lightly wiped with a cotton cloth soaked in a detergent lubricating oil. After about 5 minutes, the surface shall be cleaned. The CIL shall then be measured (paragraph 93.6)

93.13 Resistance to corrosion (ISO Standard 3768)

93.13.1 Retro-reflective devices must be so designed that they retain the prescribed photometric and colorimetric characteristics despite the humidity and corrosive influences to which they are normally exposed.

93.13.2 The retro-reflective device, or the lamp if the device is combined with a light, shall be stripped of all removable parts and subjected to the action of a saline mist for a period of 50 hours, comprising two periods of exposure of 24 hours each, separated by an interval of two hours during which the sample is allowed to dry.

93.13.3 The saline mist shall be produced by atomizing, at a temperature of 35 deg. C +/- 2 deg. C, a saline solution obtained:

93.13.3.1 In the case of moulded plastics reflectors as Classes IA, IB, IIIA, IIIB, IVA by dissolving 20 +/- 2 parts by weight of sodium chloride in 80 parts of distilled water containing not more than 0.02 per cent of impurities.

93.13.3.1.1 Immediately after completion of the test, the sample must not show signs of excessive corrosion liable to impair the efficiency of the device.

93.13.3.2 In the case of a sample unit of retro-reflective marking, By dissolving 5 parts by weight of sodium chloride in 95 parts of distilled water containing not more than 0.02 per cent of impurities.

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93.13.3.2.1 Immediately after completion of the test, the sample shall show no sign of corrosion liable to impair the efficiency of the marking.

93.13.4 The coefficient of retro-reflection R' of the retro-reflective areas, when measured after a recovery period of 48 hours as specified in paragraph 93.6, at an entrance angle of $\beta_2 = 5$ deg. and an observation angle of $\alpha = 20'$, shall be not less than the value in Table 9 or more than the value in Table 10 respectively. Before measuring, the surface shall be cleaned to remove salt deposits from the saline mist.

93.14 Resistance of the accessible rear face of mirror-backed retro-reflective devices

93.14.1 Resistance of the accessible rear face of mirror-backed retro-reflective devices, in the case of moulded plastics reflectors as Classes IA, IB, IIIA, IIIB, IVA.

93.14.2 The reverse side of the retro-reflective device shall be brushed with a hard nylon brush.

93.14.3 After having brushed in the case of moulded plastics reflectors as Classes IA, IB, IIIA, IIIB and IVA the rear face of the retro-reflective device, a cotton cloth soaked in the mixture, defined in paragraph 93.11 shall be applied to the said rear face for one minute. The cotton cloth is then removed and the retro-reflective device left to dry.

93.14.4 As soon as evaporation is completed, the reverse side shall be brushed with the same brush as before.

93.14.5 The CIL shall then be measured (paragraph 93.6) after the whole surface of the mirror-backed rear face has been covered with Indian ink.

93.15 Resistance to weathering

93.15.1 Resistance to weathering in the case of sample units of retro-reflective marking devices

93.15.1.1 Procedure - For each test, two specimens of a sample unit are taken. One specimen shall be stored in a dark and dry container for subsequent use as "reference unexposed specimen".

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- (a) The retro-reflector or retro-reflective material shall be exposed until blue standard No. 7 has faded to No. 4 on the grey scale blue standard No. 7.
- (b) The fluorescent material or fluorescent / retro-reflective material shall be exposed until blue standard No. 5 has faded to No. 4 on the grey scale.

93.15.1.2

93.15.1.3 After the test, the specimen shall be washed in a dilute neutral detergent solution, dried and examined for conformity with the requirements specified in paragraphs 93.15.1.4. and 93.15.1.5.

93.15.1.4 Visual appearance

No area of the exposed specimen shall show any evidence of cracking, scaling, splitting, blistering, delamination, distortion, chalking, staining or corrosion. The sample shall not exhibit any visible damage such as cracks, scaling or peeling of the fluorescent or of the fluorescent retro-reflecting material.

93.15.1.5 Colour fastness

The colours of the exposed specimen shall still meet the requirements specified in the paragraph 93.5. of this Regulation for the corresponding retro-reflective device.

93.15.1.6 Effect on the coefficient of retro-reflection of the retro-reflective material:

93.15.1.6.1 For this check, measurements shall be made only at an observation angle of $\alpha = 20'$ and an entrance angle of $\beta = 5 \text{ deg.}$ by the method given in paragraph 93.6.

93.15.1.6.2 The coefficient of retro-reflection of the exposed specimen when dry shall be not less than 80 per cent of the value in paragraph 93.5. of this Regulation.

93.16 Resistance to cleaning in the case of a sample unit of retro-reflective marking devices

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93.16.1 Manual cleaning

A test sample smeared with a mixture of detergent lubricating oil and graphite shall be easily cleaned without damage to the retro-reflective surface when wiped with a mild aliphatic solvent such as n-heptane, followed by washing with a neutral detergent.

93.16.2 power washing

When subjected to a continuous spraying action for 60 seconds on the test component in its normal mounting conditions, a test sample shall show no damage to the retroreflective surface or delamination from the substrate or separation from the sample mounting surface under the following set-up parameters:

- (a) Water/wash solution pressure 8 +/- 0.2MPa.
- (b) Water/wash solution temperature 60 deg. - 5 deg. C.
- (c) Water/wash solution flow rate 7 +/- 1 l/min.
- (d) The tip of the cleaning wand to be positioned at distance of 600 +/- 20 mm away from the retro-reflective surface.
- (e) Cleaning wand to be held at no greater angle than 45 degrees from perpendicular to the retro-reflective surface.
- (f) 40-degree nozzle creating wide fan pattern.

93.17 Bonding strength

93.17.1 Bonding strength (in the case of adhesive materials) for retro-reflecting markings

93.17.1.1 The adhesion of retro-reflective materials shall be determined after 24 hours curing time by utilising a 90-degree peel on a tensile strength testing machine.

93.17.1.2 The retro-reflective materials shall not be easily removable without damaging the material.

93.17.1.3 The retro-reflective materials shall need a force of at least 10 N per 25 mm width at a constant speed of 300 mm per minute to be removed from their substrate.

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93.17.2 Bonding strength (in the case of adhesive materials) for retro-reflective material for rear marking plates

93.17.2.1 The adhesion of retro-reflective materials shall be determined after 24 hours curing time by utilizing a 90-degree peel on a tensile strength testing machine.

93.17.2.2 The adhesion of laminated or coated retro-reflective and fluorescent materials shall be determined.

93.17.2.3 The coated materials, of whatever kind, shall not be removable without tools or without damaging the material.

93.17.2.4 The laminated materials (adhesive films) shall need a force of at least 10 N per 25 mm width, at a speed of 300 mm per minute, to be removed from the substrate.

93.18 Flexing - Retro-reflecting Markings

93.18.1 For samples that are to be adhered to a flexible substrate, i.e. tarpaulin, the following shall apply:

93.18.2 A specimen of the sample unit that measures 50 mm by 300 mm shall be bent once lengthwise, around a 3.2 mm mandrel with adhesive contacting the mandrel for a period of 1 second.

93.18.3 The test temperature shall be 23 deg. C +/- 2 deg. C.

93.18.4 After this test, the specimen shall not have cracking of the surface and shall not show any visible change that would reduce its effective performance.

93.19 Resistance to impact

93.19.1 Rear marking plates (except for plastics corner-cube reflectors)

When a 25 mm diameter solid steel ball is dropped from a height of 2 m onto the retroreflective and fluorescent surfaces of a supported plate, at an ambient temperature of 23 +/- 2 deg. C, the material shall show no cracking or separation from the substrate at a distance of more than 5 mm from the impacted area.

93.19.2 Retro-reflective devices of the Class IVA

The official directions are written in Chinese, this English edition is for your reference only

The retro-reflective device shall be mounted in a manner similar to the way in which it is mounted on the vehicle, but with the lens faced horizontal and directed upwards. Drop a 13 mm diameter polished solid steel ball, once, vertically onto the central part of the lens from a height of 0.76 m. The ball may be guided but not restricted in free fall. When a retro-reflective device is tested at room temperature with this method, the lens shall not crack.

93.20 Rigidity of plates

93.20.1 Classes 1, 2, 3, 4 and 5

93.20.1.1 The rear marking plate shall be placed on two supports in such a way that the supports are parallel to the shorter edge of the plate and the distance from either support to the adjacent edge of the plate shall not exceed $L/10$, where L is the greater overall dimension of the plate. The plate shall then be loaded with bags of shot or of dry sand to a uniformly distributed pressure of 1.5 kN/m^2 . The deflection of the plate shall be measured at a point midway between the supports.

93.20.1.2 When tested as described in paragraph 93.20.1.1 above, the maximum deflection of the plate under the test load shall not exceed one twentieth of the distance between the supports in paragraph 93.20.1.1 and the residual deflection after removal of the load shall not exceed one fifth of the measured deflection under load.