

3 when measured at each of the two rotation angles defined in Section 8.3.

**Table 3 Color, combined-performance retroreflective material**

Color	chromaticity coordinates		Minimum luminance factor 8 min
	x	y	
Fluorescent yellow-green	0.387	0.610	0.70
	0.356	0.494	
	0.398	0.452	
	0.460	0.540	
Fluorescent orange-red	0.610	0.390	0.40
	0.535	0.375	
	0.570	0.340	
	0.655	0.344	
Fluorescent red	0.655	0.344	0.25
	0.570	0.340	
	0.595	0.315	
	0.690	0.310	

#### 6.1.3 Colorfastness of Combined-Performance Materials After Xenon Test

The color after exposure shall be within the areas defined by the coordinates in Table 3 and the luminance factor shall be not less than the corresponding minimum values in Table 3. The light fastness of the test sample shall be determined in accordance with ISO 105-B02:1994 Method 1. Exposure shall continue until the blue scale control standard number 5 has changed to step 3 for red and orange-red materials, and for yellow materials the blue scale control standard number 4 has changed to step 4 of the gray scale.

#### 6.2 Color Fastness of Background Material

##### 6.2.1 Color Fastness to Crocking

The color fastness to crocking both wet and dry should be at least a grade 4.0 by the Gray Scale for Staining in accordance with AATCC 8-1996.

#### 6.2.2 Color Fastness to Perspiration

The color fastness to perspiration should be at least a grade 4.0 for color change by the Gray Scale for Color Change and at least a grade 3.0 for staining by the Gray Scale for Staining in accordance with AATCC 15-1997.

#### 6.2.3 Color Fastness — When Laundered, Dry-cleaned, Hypochlorite Bleached and Hot-pressed

When the care label requirements are as specified in Table 4 the color fastness shall be determined in accordance with the performance requirements and test methods stated in Table 4.

Specimens shall be dried hanging in air at a temperature not exceeding 60°C with parts in contact only at the lines of stitching.

**Hot-pressing:** Samples shall be pressed in the dry state only. The hot-pressing shall be tested in accordance with the ironing instructions on the garment care label, where

- (.) is a temperature of  $(110 \pm 2)^\circ\text{C}$ ,
- (..) is  $(150 \pm 2)^\circ\text{C}$  and
- (...) is  $(200 \pm 2)^\circ\text{C}$ .

#### 6.2.4 Colorfastness of Background Materials After Xenon Test

The color after exposure shall be within the areas defined by the coordinates in Table 2 and the luminance factor shall be not less than the corresponding minimum values in Table 2.

The light fastness of the test sample shall be determined in accordance with AATCC 16-1993 (Test Option E). Expose the materials to 40 AATCC Fading Units.

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**Table 4 Colorfastness**

Care process	Fastness, grade of the gray scale, at least	Test method
Domestic and commercial laundry	Color change: Grade 4.5; Staining: Grade 3.0	AATCC 61-1996
Dry-cleaning	Color shade change: 4	AATCC 132-1993
Hypochlorite bleaching Domestic	Color shade change: 4 (Test condition 5A)	AATCC 61-1996
Commercial	(Test condition 4A)	
Hot-pressing	Color change: 4 to 5 Staining: 3.0	AATCC 133-1994
Water	Color change & Staining: Grade 4	AATCC 107-1997

**6.3 Dimensional Change of Background Material**

**6.3.1** The dimensional change of background material shall not exceed  $\pm 4\%$  in length and  $\pm 2\%$  in width.

**6.3.2** Preparation of the specimen material shall be done in accordance with ASTM D1776 - 90.

**6.3.3** For dimensional change caused by washing or dry-cleaning, one sample prepared in accordance with Section 6.3.2 shall be subjected to five cleaning cycles in accordance with AATCC 135-1995 (3) (III) (A) (iii) for home laundering, and in accordance with AATCC 96-1997 (IIIc) (A) (E) for commercial laundering.

**6.4 Mechanical Properties of Background Materials****6.4.1 Tensile Strength of Woven Materials**

Performance requirements:

- minimum 445 N (100 lbs) lengthwise
- minimum 445 N (100 lbs) crosswise

Tensile strength shall be tested in accordance with ASTM D5034-95 (G-E). Test samples shall be 60 mm x 300 mm. The cross head traverse speed (rate of deformation) shall be (100  $\pm$  10) mm/min. The samples shall be tested in the dry state only.

**6.4.2 Bursting Strength of Knitted Materials**

The minimum bursting strength shall be 267 N (60 lbs). Bursting strength shall be tested in accordance with ASTM D-3787 using sample specimens of 30 mm diameter.

**6.4.3 Tear Resistance of Woven Materials (Uncoated, Coated or Laminate)**

Background materials for high-visibility safety apparel shall be tested in accordance with ASTM D1424-89 at a minimum requirement of 13 N (1360 grams).

**6.5 Resistance to Water Penetration**

Background material for high-visibility safety apparel which is to be marketed as providing protection during rainfall shall be tested in accordance with AATCC 35-1994 (Rain Test) using a pressure head setting of 2 feet, and a continuous water spray for 2 minutes. The average water penetration shall be less than or equal to 1.0 gram of water penetration for Level 1; and AATCC 127-1995 (Hydrostatic Head) testing with water to the face side with a minimum requirement of 200 cm. originally and after five launderings.

### 6.5.1 Water Repellency

Background material for high-visibility safety apparel which is to be marketed as providing protection during rainfall shall be tested in accordance with AATCC 22-1996 Spray Test, with an original requirement of 90 and after five laundry cycles of 70.

### 6.6 Water Vapor Permeability for Background Materials Classified as Breathable

Background material for high-visibility safety apparel which is to be marketed as providing protection during rainfall, and classified as breathable, shall be tested in accordance with ASTM E96 Procedure B - (upright) with a minimum requirement not lower than 600 g/m<sup>2</sup>/24 hours for uncoated and microporous materials; and Procedure BW- (inverted) with a minimum requirement not lower than 3,600 g/m<sup>2</sup>/24 hours for hydrophilic materials.

### 6.7 Ergonomics

High visibility safety apparel shall be designed and manufactured to meet the following requirements:

The materials and components of the high visibility safety apparel should not be known to adversely affect the wearer.

The high visibility safety apparel should offer the wearer the best possible degree of comfort that is consonant with the provision of adequate protection.

Parts of the high visibility safety apparel that come into contact with the end user should be free of roughness, sharp edges and projections that could cause excessive irritation or injuries.

High visibility safety apparel should facilitate its correct positioning on the user and should ensure that it remains in place for the foreseeable period of use, taking into account ambient factors, together with the movements and postures that the wearer could adopt during the course of work. For this purpose, appropriate means, such as

adequate size ranges, should be provided so as to enable high visibility safety apparel to be adapted to the morphology of the user. High visibility warning clothing should be a light as possible without prejudice to the design strength and efficiency.

## 7. Photometric and Physical Performance Requirements for Retroreflective Materials

### 7.1 Performance Requirements of Retroreflective Material Prior to Test Exposure

Retroreflective materials shall comply with the requirements of Table 5 or 6, as applicable, before test exposures.

Measurements shall be made by the method described in Section 8.3.

When measured at the two rotation angles  $\varepsilon_1 = 0^\circ$  and  $\varepsilon_2 = 90^\circ$ , retroreflective material shall comply with the minimum requirements for the coefficient of retroreflection stated in Table 5 or 6, as appropriate, at one of the two rotation angles; and shall be not less than 75% of the values stated in Table 5 or 6, as appropriate, at the other rotation angle.

The values for retroreflective material are for any color.

**Table 5 Minimum coefficient of retroreflection in cd/(lx · m<sup>2</sup>) for Level 2 retroreflective or combined-performance retroreflective material**

Observation angle	Entrance angle			
	5°	20°	30°	40°
12°	330	290	180	65
20°	250	200	170	60
1°	25	15	12	10
1°30'	10	7	5	4

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<b>Table 6 Minimum coefficient of retroreflection in cd/(lx · m<sup>2</sup>) for Level 1 retroreflective or combined-performance retroreflective material</b>				
Observation angle	Entrance angle			
	5°	20°	30°	40°
12'	250	220	135	50
20'	120	100	75	30
1°	25	15	12	10
1°30'	10	7	5	4

## 7.2 Performance Requirements of Retroreflective Material after Test Exposure

The samples tested in accordance with Section 7.1 shall be exposed as specified in Table 7. After exposure each test specimen shall fulfill the photometric requirements of Section 7.2.1.

### 7.2.1 Retroreflective Materials

The coefficient of retroreflection  $R_A$ , measured at observation angle 12° and entrance angle 5°, shall exceed 100 cd/(lx · m<sup>2</sup>) at one of the two orientations described in 8.3 and shall be not less than 75% of those required values at the other orientation.

## 8. Test Methods

### 8.1 Sampling and Conditioning

**Specimens:** Test specimens shall be taken at random from commercially available quantities representative of commercially available quality.

**Preparation of specimens:** The size, shape and quantity, shall be as required for each test procedure.

**Number of tests:** Unless otherwise specified, one specimen of each material shall be tested and shall comply with the minimum requirements.

**Conditioning of specimens:** The specimens shall be conditioned for at least 24 hours at (20 ± 2)°C and (65 ± 5) % relative humidity. If the tests are carried out in other conditions, the tests shall be conducted within 5 minutes after withdrawal from the conditioning atmosphere.

### 8.2 Determination of Color

The color shall be measured in accordance with the procedures defined in ASTM E1164-94 with polychromatic illumination D65 and 45/0 (or 0/45) geometry and 2° standard observer. The specimen shall have a black underlay with a reflectance of less than 0.04.

### 8.3 Method for Determination of Retroreflective Photometric Performance

The coefficient of retroreflection  $R_A$  shall be determined in accordance with the procedure defined in ASTM E808-94 and E809-94.

Measurements shall be made on square samples of 10 cm x 10 cm or of the size of the pretested samples.

$R_A$  for the sample shall be measured at the specified observation angle and entrance angle for both the 0°, and 90° positions of the rotation angle  $\alpha$ . The position 0° is determined by one of the following means:

- a clear datum mark on each sample;
- a clear instruction given by the manufacturer of the material.

If no mark or instruction exists, the position  $\alpha = 0°$  can be chosen at random.

**Table 7 Test Exposure**

<b>Test Exposure</b>	Retroreflective and Combined-performance retroreflective material
<b>Abrasion</b>	Paragraph 8.4.1
<b>Flexing</b>	Paragraph 8.4.2
<b>Folding at cold temperatures</b>	Paragraph 8.4.3
<b>Temperature variation</b>	Paragraph 8.4.4
<b>Washing</b>	Paragraph 8.4.6
<b>Dry-cleaning</b>	Paragraph 8.4.7
<b>Influence of rainfall</b>	Paragraph 8.4.8

**8.4 Retroreflection after Test**b) 20 hours at  $(-30 \pm 2)^\circ\text{C}$ ;

conditioning for at least 2 hours in accordance with Section 8.1.

**8.4.1 Abrasion**

The test sample shall be abraded in accordance with EN 530:1994, Method 2, using a woolen fabric abradent. The specimens shall be measured after 5,000 cycles, using a weight of 9kPa.

**8.4.2 Flexing**

The test sample shall be flexed in accordance with ISO 7854:1995, Method A. The specimens shall be measured after 7,500 cycles.

**8.4.3 Folding at Cold Temperatures**

The test sample shall be exposed and folded in accordance with ISO 4675:1990 at a temperature of  $(-20 \pm 1)^\circ\text{C}$ .

Measurements shall be made after reconditioning to the atmosphere in accordance with Section 8.1 for at least 2 hours.

**8.4.4 Exposure to Temperature Variation**

Specimens of the size of 180 mm x 30 mm shall be exposed continuously to a cycle of changing temperatures:

a) for 12 hours at  $(50 \pm 2)^\circ\text{C}$  immediately followed by

**8.4.5 Washing, Dry-cleaning**

When the care label in the garment indicates that it is suitable for washing, the retroreflective material shall meet the minimum performance requirements of Section 7.2, after a minimum of five washing cycles. The procedure defined in Section 8.4.6 shall be applied. When the care label in the garment indicates that it is suitable for dry-cleaning, the procedure defined in Section 8.4.7 shall be applied. When the care label indicates that the garment is suitable for both washing and dry-cleaning, the procedure defined in Sections 8.4.6 and 8.4.7 shall be applied separately on separate test samples.

**8.4.6 Washing According to Care Label**

Three clothing fabric specimens 300 mm x 250 mm shall be prepared with two stripes of retroreflective material (Level 2 or Level 1), each 250 mm x 30 mm, with a distance between the two stripes of 30 mm.

The test samples shall be washed in accordance with ISO 6330:1984, Method 2A. The specified wash cycle shall be applied to the test sample for the number of times stated in the label (see clause 9 and 10). After the last wash cycle the samples shall be dried, stress free, at  $(50 \pm 5)^\circ\text{C}$ .

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