INTERNATIONAL STANDARD

ISO 20471

First edition
2013-03-15

Corrected version
2013-06-01

High visibility clothing — Test methods and requirements

Vêtements à haute visibilité — Méthodes d'essai et exigences

Reference number
ISO 20471:2013(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20471 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

This corrected version of ISO 20471:2013 incorporates the following correction:

— in the fourth paragraph of subclause 4.1 the requirement concerning the sleeves of a class 3 garment has been corrected.

Introduction

The performance of the conspicuity-enhancing materials to be used for high risk-related visibility clothing is specified photometrically together with minimum areas and placement (design) requirements.

Conspicuity is the property that makes an object readily attract visual attention. This is a particularly important feature in complex environments which have visually competing objects. Conspicuity is determined by an object's luminance contrast, colour contrast, pattern and design, and motion characteristics relative to the ambient background against which it is seen.

Three classes of garment are defined based on three different minimum areas of retroreflective, fluorescent and/or combined performance materials. Each of these classes will provide a different level of conspicuity, class 3 being the class that provides the highest degree of conspicuity against most backgrounds found in urban and rural situations in daylight and in night time. Users should select the required class of performance based on a risk assessment of the location/situation in which the protection afforded by clothing to this International Standard is required.

This International Standard contains requirements relating to risk assessment and risk analysis of high visibility garments. Possible designs illustrating the placement of retroreflective materials are included within the standard. Ergonomic factors such as fit/sizing, comfort, and range of motion of the wearer should be considered when selecting the most appropriate configuration of retroreflective and fluorescent materials within the garment.

Selection and use of high visibility clothing can vary among user countries and may be subject to local regulations. This International Standard contains requirements relating to risk assessment of the condition in which the high visibility clothing is to be used. This will involve consideration of the factors which may affect an observer's ability to detect that a person is present. The observer needs both to perceive and to recognize the wearer and then needs to be able to take appropriate avoidance action. The wearing of a conspicuity-enhancing high visibility garment does not guarantee that the wearer will be visible under all conditions.

The minimum requirements given within this International Standard are determined by the specific test methods and their assigned measuring values. The tests are partly performed on new materials and partly on preconditioned materials. By preconditioning (e.g. folding of retroreflective material) a load of the materials is simulated. However, it should be noted that laboratory testing may not represent real life conditions. The conspicuity performance of a garment will depend on usage (e.g. dirt, solar irradiation), care (e.g. cleaning agent, repair), storage (e.g. dust-free, lightproof), etc.

High visibility clothing — Test methods and requirements

1 Scope

This International Standard specifies requirements for high visibility clothing which is capable of visually signalling the user's presence. The high visibility clothing is intended to provide conspicuity of the wearer in any light condition when viewed by operators of vehicles or other mechanized equipment during daylight conditions and under illumination of headlights in the dark. For further information concerning risk situations, see Annex A.

This International Standard is not applicable to medium-risk and low-risk situations.

Performance requirements are included for colour and retroreflection as well as for the minimum areas and for the placement of the materials in protective clothing.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 105-A02, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour*

ISO 105-A03, *Textiles — Tests for colour fastness — Part A03: Grey scale for assessing staining*

ISO 105-B02:1994, *Textiles — Tests for colour fastness — Part B02: Colour fastness to artificial light: Xenon arc fading lamp test*

ISO 105-C06, *Textiles — Tests for colour fastness — Part C06: Colour fastness to domestic and commercial laundering*

ISO 105-D01, *Textiles — Tests for colour fastness — Part D01: Colour fastness to drycleaning using perchloroethylene solvent*

ISO 105-E04, *Textiles — Tests for colour fastness — Part E04: Colour fastness to perspiration — Part E04: Colour fastness to perspiration*

ISO 105-N01, *Textiles — Tests for colour fastness — Part N01: Colour fastness to bleaching: Hypochlorite — Tests for colour fastness — Part N01: Colour fastness to bleaching: Hypochlorite*

ISO 105-X11, *Textiles — Tests for colour fastness — Part X11: Colour fastness to hot pressing — Tests for colour fastness — Part X11: Colour fastness to hot pressing*

ISO 105-X12, *Textiles — Tests for colour fastness — Part X12: Colour fastness to rubbing*

ISO 1421:1998, *Rubber- or plastics-coated fabrics — Determination of tensile strength and elongation at break*

ISO 4674-1:2003, *Rubber- or plastics-coated fabrics — Determination of tear resistance — Part 1: Constant rate of tear methods*

ISO 4675, *Rubber- or plastics-coated fabrics — Low-temperature bend test*

ISO 7854:1995, *Rubber- or plastics-coated fabrics — Determination of resistance to damage by flexing*

ISO 11092, *Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*

ISO 12947-2, *Textiles — Determination of the abrasion resistance of fabrics by the Martindale method — Part 2: Determination of specimen breakdown*

ISO 13688:1998, *Protective clothing — General requirements*

ISO 13934-1, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13938 (all parts), *Textiles — Bursting properties of fabrics*

EN 343, *Protective clothing — Protection against rain*

CIE 15, *Colorimetry*

CIE 54.2, *Retroreflection — Definition and measurement*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
high visibility clothing
warning clothing intended to provide improved conspicuity in situations where the risk of not being seen is high

3.2
fluorescent material
material that emits electromagnetic radiation at visible wavelengths longer than those absorbed

3.3
background material
coloured fluorescent material intended to be highly conspicuous, but not intended to comply with the requirements of this International Standard for retroreflective material

3.4
retroreflective material
material which is a retroreflector but which is not intended to comply with the requirements of this International Standard for background material

3.5
separate-performance material
material intended to exhibit either background or retroreflective properties but not both

3.6
combined-performance material
material intended to exhibit both background and retroreflective properties

3.7
orientation-sensitive material
material having coefficients of retroreflection that differ by more than 15 % when measured at the two rotation angles $\varepsilon_1 = 0°$ and $\varepsilon_2 = 90°$

3.8
torso
thorax and abdomen or section of the body to which the limbs, head and neck are attached

3.9
long sleeve
(1/1 arm)
part of a garment that is completely covering the arm

3.10
road
traffic-related area with moving vehicles

EXAMPLE Cycling path, harbour, airport, railway track and car park.

3.11
active road user
person on the road, participating in the traffic and with the attention on the traffic

Note 1 to entry: e.g. cyclist using the road and pedestrian using the road.

3.12
passive road user
person on the road, not participating in vehicular traffic and with attention focused on something other than traffic

EXAMPLE Road worker, person in emergency situation.

3.13
outer shell
outermost material of which the warning clothing is made

4 Design

4.1 Types and classes

High visibility clothing is grouped into three classes related to risk assessment. Each class shall have minimum areas of high visibility materials incorporated in the garment in accordance with Table 1. Garments shall comprise the required areas of background material and retroreflective material or alternatively shall comprise the required area of combined performance material. The area shall be measured on the smallest garment size available with all fasteners adjusted to the smallest configuration possible.

The garment shall be made up of high visibility material on all sides. To ensure visibility from all sides (360° visibility), it is important that horizontal retroreflective bands and fluorescent materials encircle torso, trouser legs and sleeves.

The performance class can be obtained using a single garment or a clothing ensemble, e.g. jacket and trousers. An assembly, e.g. a classified trouser and a classified jacket, can be classified as a higher class if the assembly meets the minimum requirement achieved by the actually visible area when wearing the garment. This higher class shall be additionally specified in both the information for use and on the labels of both garments (see Clause 8).

Regardless of the area of materials used, a class 3 garment shall cover the torso and shall have as a minimum either sleeves with retroreflective bands or full length trouser legs with retroreflective bands, if not both.

Table 1 — Minimum required areas of visible material in m^2

Material	Class 3 garments	Class 2 garments	Class 1 garments
Background material	0,80	0,50	0,14
Retroreflective material	0,20	0,13	0,10
Combined performance material	n. a.	n. a.	0,20
NOTE The clothing class is determined by the lowest area of visible material.			

The minimum visible area requirements to achieve a garment classification in Table 1 are not to be reduced or compromised due to the presence of any logos, lettering, labels etc.

At least (50 ± 10) % of the minimum area of visible background material shall be on the front part of the garment. Only those areas of retroreflective materials that comply with the design requirements of 4.2 shall be used in the assessment of the minimum required area of retroreflective areas. When using two or more background materials, the total area usable regardless of colour shall be measured. The garment is to be measured flat on the table including torso, arms and legs.

NOTE For additional information on high visibility garment design, see Annex D.

4.2 Specific design requirements

4.2.1 Garments covering only the torso

The background material shall encircle the torso and shall maintain a minimum width (height) of 50 mm. Interruptions of background material by retroreflective stripes are not counted. Bands of retroreflective material shall be at least 50 mm wide.

Garments only covering the torso shall have one or more bands of retroreflective material encircling the torso with a maximum inclination of ± 20° to the horizontal and bands of retroreflective material joining the torso band from the front to the back over each shoulder. The bottom of the lowest torso band shall be at least 50 mm above the bottom edge. If more than one horizontal band is applied the horizontal bands shall be at least 50 mm apart.

Alternatively, garments covering only the torso shall have two bands of retroreflective material at least 50 mm apart and encircling the torso with a maximum inclination of ± 20° to the horizontal. The bottom of the lowest torso band shall be at least 50 mm above the bottom edge.

Tabards shall be constructed so that a person of the size for which they are designed can wear the tabard so that any gaps at the sides shall not be greater than 50 mm horizontally.

Any gap (for fastening systems and seams) in the lengthwise continuity of each band of retroreflective or combined performance material shall not be greater than 50 mm, measured parallel to the direction of the band, and the total of such gaps shall not be greater than 100 mm in any one band around the torso.

Examples of garments covering only the torso are given in Figure 1.

Dimensions in millimetres

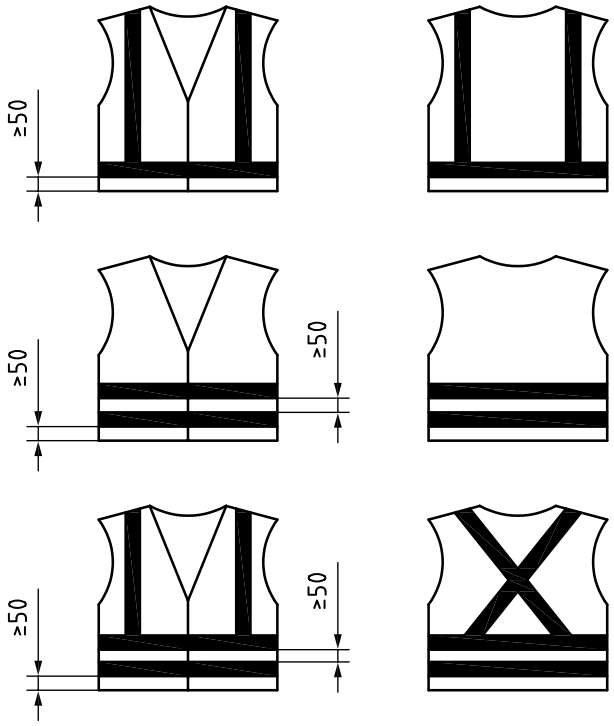


Figure 1 — Examples of garments covering only the torso

NOTE Examples of garments covering only the torso are vests and tabards.

4.2.2 Garments covering torso and arms

The background material shall encircle the torso and the sleeves and shall maintain a minimum width (height) of 50 mm. Interruptions by retroreflective stripes are not counted. Bands of retroreflective material shall be at least 50 mm wide.

Garments covering the torso and arms shall have one or more bands of retroreflective material encircling the torso with a maximum inclination of ± 20° to the horizontal and bands of retroreflective material joining the torso band from the front to the back over each shoulder. The bottom of the lowest torso band shall be at least 50 mm above the bottom edge. If more than one horizontal band is applied, the horizontal bands shall be at least 50 mm apart.

Alternatively, garments covering torso and arms shall have two or more bands of retroreflective material at least 50 mm apart and encircling the torso with a maximum inclination of ± 20° to the horizontal. The bottom of the lowest torso band shall be at least 50 mm above the bottom edge.

If a sleeve blocks a clear view of a horizontal torso band, then the sleeve shall be encircled by a retroreflective band. If it is a long sleeve (1/1 arm) garment, the sleeve shall be encircled by two bands of retroreflective material at least 50 mm apart.

If a sleeve blocks a clear view of two horizontal torso bands, then the sleeve shall be encircled with two retroreflective bands at least 50 mm apart with the lower band at least 50 mm above the sleeve edge. Testing regarding the clear view shall be done by visual inspection while moving the arm in all positions.

Any gap (for fastening systems and seams) in the lengthwise continuity of each band of retroreflective or combined performance material shall not be greater than 50 mm, measured parallel to the direction of the band, and the total of such gaps shall not be greater than 100 mm in any one band around the torso and 50 mm around the sleeves.

Examples for garments covering the torso and arms are given in Figure 2.

Dimensions in millimetres

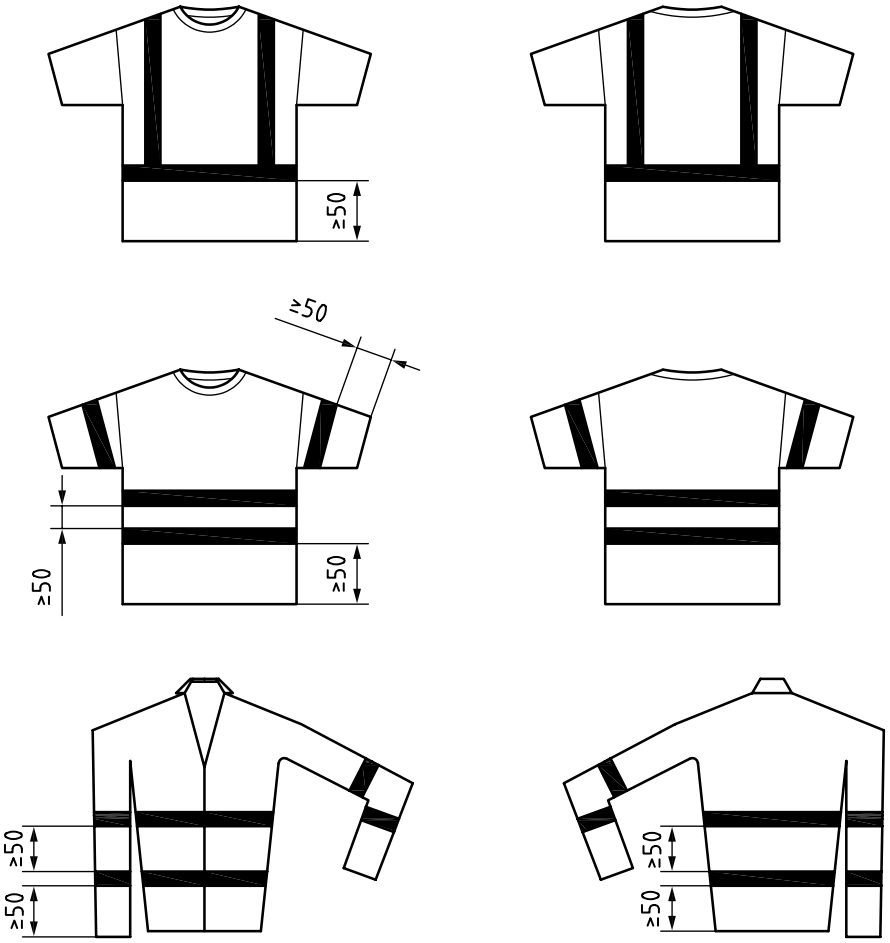


Figure 2 — Examples of garments covering torso and arms

NOTE Examples of garments covering torso and arms are jackets, shirts, coats and t-shirts.

4.2.3 Garments covering legs

The background material shall encircle the trouser legs and shall maintain a minimum width (height) of 50 mm. Interruptions by retroreflective stripes are not counted. Bands of retroreflective material shall be at least 50 mm wide.

Garments covering legs shall have two or more bands of retroreflective material at least 50 mm apart and encircling each leg with a maximum inclination of ± 20° to the horizontal. The bottom of the lower band shall be at least 50 mm above the bottom of the trouser leg.

Any gap (for fastening systems and seams) in the lengthwise continuity of each band of retroreflective or combined performance material shall not be greater than 50 mm, measured parallel to the direction of the band.

Examples for garments covering legs are given in Figure 3.

Dimensions in millimetres

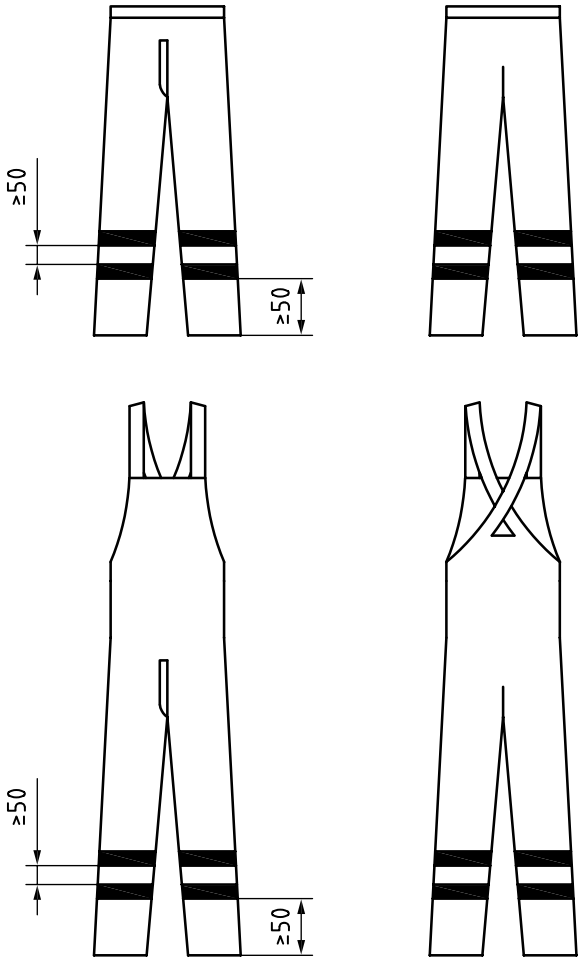


Figure 3 — Examples of garments covering legs

NOTE Examples of garments covering legs are trousers, shorts, bermudas, waistband trousers and bib and brace.

4.2.4 Garments covering torso and legs

The background material shall encircle the torso and trouser legs and shall maintain a minimum width (height) of 50 mm. Interruptions by retroreflective stripes are not counted. Bands of retroreflective material shall be at least 50 mm wide.

The requirements of 4.2.1 and 4.2.3 shall be applied.

An example of a garment covering the torso and legs is given in Figure 4.

Dimensions in millimetres

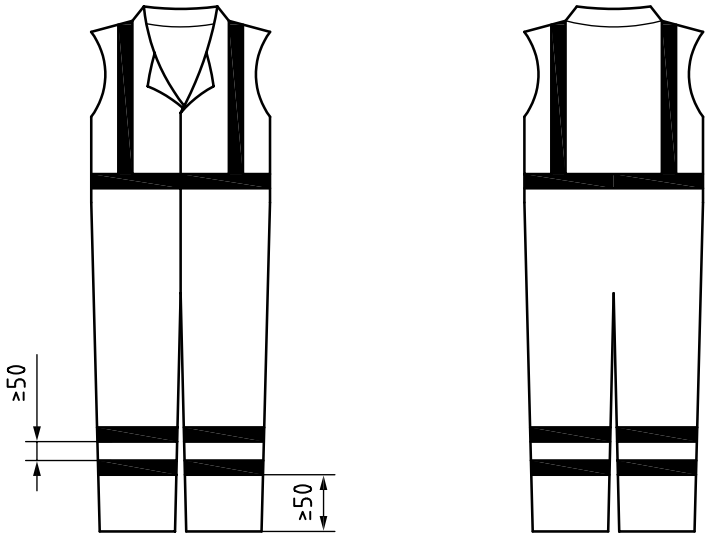


Figure 4 — An example of garments covering torso and legs

NOTE An example of a garment covering torso and legs is coveralls without sleeves.

4.2.5 Garments covering torso, arms and legs

The background material shall encircle the torso, the sleeves and trouser legs and shall maintain a minimum width of 50 mm (in height). Interruptions by retroreflective stripes are not counted. Bands of retroreflective material shall be at least 50 mm wide.

The requirements of 4.2.2. and 4.2.3. shall be applied.

Examples for garments covering torso, arms and legs are given in Figure 5.

Dimensions in millimetres

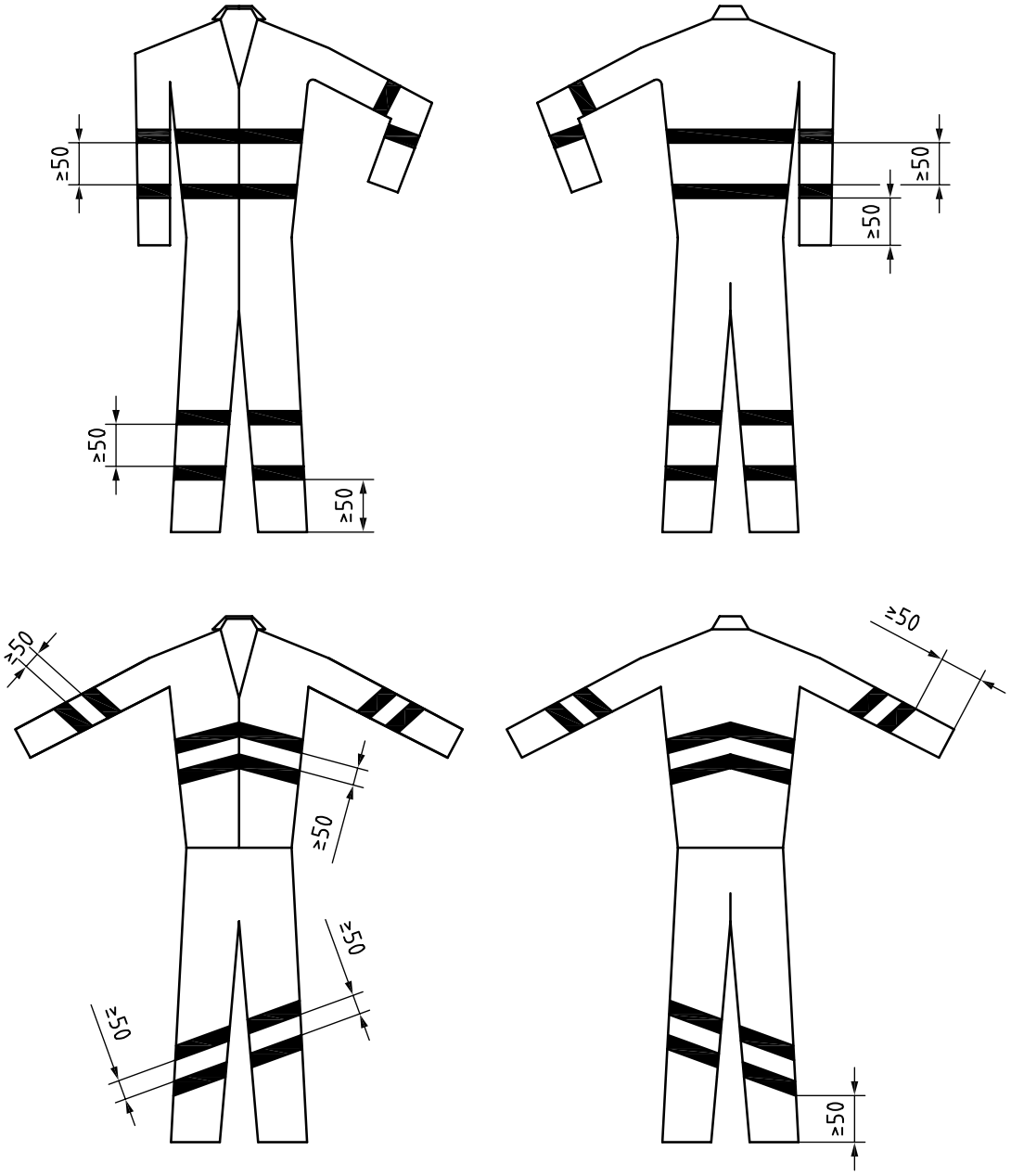


Figure 5 — Example of garments covering torso, arms and legs

NOTE An example of a garment covering torso, arms and legs is coveralls with sleeves.

4.3 Size designation

The size designation shall be in accordance with the requirements of ISO 13688.

5 Requirements for background material, non-fluorescent material and combined performance material

5.1 Colour performance requirements of new material

5.1.1 Background material

When tested according to 7.2, the chromaticity coordinates and the luminance factors shall comply with the requirements of Table 2.

5.1.2 Combined performance material

When tested according to 7.2, the chromaticity coordinates and the luminance factors shall comply with the requirements of Table 2.

The mean luminance factor of orientation-sensitive retroreflective material shall comply with the requirements of Table 2 when measured at the two rotation angles 0° and 90° as defined in 7.3.

The mean chromaticity of orientation-sensitive retroreflective material shall comply with the requirements of Table 2 when measured at the two rotation angles 0° and 90° as defined in 7.3.

Table 2 — Colour requirements for background and combined performance material

Colour	Chromaticity coordinates *x y*		Minimum luminance factor β_{min}
Fluorescent yellow	0,387 0,356 0,398 0,460	0,610 0,494 0,452 0,540	0,70
Fluorescent orange-red	0,610 0,535 0,570 0,655	0,390 0,375 0,340 0,345	0,40
Fluorescent red	0,655 0,570 0,595 0,690	0,345 0,340 0,315 0,310	0,25

5.2 Colour after Xenon test

The colour after exposure shall be within the areas defined by the coordinates in Table 2 for background materials and combined performance materials and its luminance factor shall comply with the minimum value for the luminance factor (Table 2) of the colour that is obtained on exposure to Xenon light e.g. a fluorescent red is acceptable if after exposure to Xenon light its colour-coordinates are within the tolerated area for orange-red and if its luminance factor is higher than 0,4. The exposure of the test sample shall be performed in accordance with ISO 105-B02:1994, method 3. Exposure shall continue until the blue scale control standard number 5 has changed to grade 3 of the grey scale for red and orange-red materials and for yellow materials the blue scale control standard number 4 has changed to grade 4 of the grey scale according to ISO 105-A02.

If the colour changes from one colourbox to another, this shall be mentioned in the instructions for use.

5.3 Colour fastness of background material and all non-fluorescent material layers after test exposure

5.3.1 Colour fastness to rubbing

The test shall be conducted in accordance with ISO 105-X12. The colour fastness to rubbing (dry), when assessed with ISO 105-A03, shall be at least grade 4 of the grey scale.

5.3.2 Colour fastness to perspiration

The test shall be conducted in accordance with ISO 105-E04. For background material, the colour fastness, when assessed with ISO 105-A02, shall be at least grade 4 of the grey scale for the colour change of the specimen. Background material and all non-fluorescent material layers, when assessed with ISO 105-A03, shall be at least grade 4 of the grey scale with respect to staining.

5.3.3 Colour fastness when laundered, dry cleaned, hypochlorite bleached and hot pressed

According to the care recommendation of the garment, the colour fastness shall be determined in accordance with the performance requirements and test methods of Table 3.

Table 3 — Colour fastnesses

Care process	Minimum fastness grade of the grey scale[a]		Test method
	Background material	**Non-fluorescent material** (without reflective and combined performance material)	
Laundry	Colour change: 4-5 Staining: 4	Staining: 4	Domestic: ISO 105-C06[b] or Industry: ISO 105-C06, test number E2S
Dry cleaning	Colour change: 4 Staining: 4	Staining: 4	ISO 105-D01
Hypochlorite bleaching	Colour change: 4		ISO 105-N01
Hot pressing	Colour change: 4-5 Staining: 4	Staining: 4	ISO 105-X11 (condition dry/dry)

[a] According to ISO 105-A02 and ISO 105-A03.

[b] According to care recommendations (see ISO 3758).

Select only the fibre corresponding to the fibres of the background material and non-fluorescent material.

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

5.4 Dimensional change of background material and non-fluorescent material

5.4.1 The requirements and testing procedures for dimensional change on materials shall comply with ISO 13688.

5.4.2 For knitted materials, the dimensional change shall not exceed ± 5 % in both length and width.

5.5 Mechanical properties for background material and non-fluorescent material

5.5.1 Tensile strength of woven material

The tensile strength in weft and warp direction shall fulfil the following requirements:

— tensile strength shall be ≥ 100 N;

— tensile strength shall be tested in accordance with ISO 13934-1.

5.5.2 Bursting strength of knitted materials

When tested in accordance with ISO 13938-1 or ISO 13938-2 using a 50 cm^2 test area, the burst strength of knitted outer material shall have a mean minimum of 100 kPa or, using a 7,3 cm^2 test area, shall be a minimum of 200 kPa.

5.5.3 Tensile strength and tear resistance of coated fabrics and laminates

Outer shell materials for high visibility clothing shall be tested according to ISO 1421:1998, method 1, for tensile strength and have a minimum of 100 N. For materials with an elongation of more than 50 %, this requirement is not applicable. Tear resistance shall be determined in accordance with ISO 4674-1:2003, method A, and have a minimum of 20 N. For materials with an elongation of more than 50 %, this requirement is not applicable.

5.6 Physiological performance — Water vapour and thermal resistance

5.6.1 Garments with the exception of tabards and waistcoats shall comply with 5.6.2 or 5.6.3.

5.6.2 For garments which offer protection against rain (coated woven and knitted fabrics and laminates), test and classify in accordance with EN 343.

5.6.3 For other single or multilayer garments, the water vapour resistance shall be equal or lower than 5 m^2 Pa/W.

If the water vapour resistance exceeds 5 m^2 Pa/W, the thermal resistance according to ISO 11092 shall be measured and the water vapour permeability index shall be determined. The water vapour permeability index shall be ≥ 0,15.

The ergonomic requirements of ISO 13688:1998, 4.3 (design) and 4.4 (comfort), shall be met.

6 Photometric performance requirements for retroreflective material and combined performance material after physical exposure

6.1 Retroreflective performance requirements of new material

Separate performance retroreflective material and combined performance material shall comply with the requirements of Tables 4 or 5, as applicable, before test exposures. Measurements shall be made by the method described in 7.3.

When measured at the two rotation angles $\varepsilon_1 = 0°$ and $\varepsilon_2 = 90°$, materials having coefficients of retroreflection that differ by more than 15 % are defined as orientation sensitive.

Orientation-sensitive material shall comply with the minimum requirements for the coefficient of retroreflection stated in Table 4 or Table 5, as appropriate, at one of the two rotation angles described in 7.3; the coefficient of retroreflection shall be not less than 75 % of the values stated in Table 4 or Table 5, as appropriate, at the other rotation angle.

Table 4 — Minimum coefficient of retroreflection in cd/(lx · m²) for separate performance retroreflective material

Observation angle	Entrance angle β_1 ($\beta_2 = 0$)			
	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

Table 5 — Minimum coefficient of retroreflection in cd/(lx · m²) for combined performance material

Observation angle	Entrance angle β_1 ($\beta_2 = 0$)			
	5°	20°	30°	40°
12′	65	50	20	5
20′	25	20	5	1,75
1°	5	4	3	1
1°30′	1,5	1	1	0,5

The values for combined performance materials are for any colour.

6.2 Retroreflective performance requirements after test exposure

6.2.1 General

The samples tested in accordance with 6.1 shall be exposed as specified in Table 6. After exposure, each test specimen shall fulfil the photometric requirements of 6.2.2, 6.2.3 and 6.2.4, when measured in accordance with 7.3, as applicable.

Table 6 — Test exposure

Exposure	Separate performance retroreflective material	Combined performance material
Abrasion	7.4.1	7.4.1
Flexing	7.4.2	7.4.2
Folding at cold temperatures	7.4.3	7.4.3
Temperature variation	7.4.4	7.4.4
Rainfall	7.4.5	7.4.5
Washing	7.5.2	7.5.2
Dry cleaning	7.5.3	7.5.3

6.2.2 Separate performance retroreflective material

The coefficient of retroreflection, *R′*, for separate performance retroreflective materials shall exceed 100 cd/(lx · m²) at observation angle 12° and entrance angle 5°.

6.2.3 Combined performance material

The coefficient of retroreflection R' for combined performance material shall exceed 30 cd/(lx · m²) measured at observation angle 12' and entrance angle 5°. When determining the influence of rainfall in accordance with 7.4.5, the coefficient of retroreflection shall exceed 15 cd/(lx · m²).

6.2.4 Orientation-sensitive materials

The coefficient of retroreflection R' for orientation-sensitive material after exposure shall comply with the same requirements of 6.2.2 or 6.2.3, as appropriate, at one of the two orientations described in 7.3 and shall be not less than 75 % of those required values at the other orientation.

7 Test methods

7.1 Sampling and conditioning

Samples for testing shall be taken from the original garment or from material or materials used in the finished garment. The size, shape and quantity shall be as required for each test procedure.

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

The specimens shall be conditioned for at least 24 h at (20 ± 2) °C and (65 ± 5) % relative humidity. If the test is carried out in other conditions, the test shall begin within 5 min after withdrawal from the conditioning atmosphere.

7.2 Determination of colour

The colour shall be measured in accordance with the procedures defined in CIE 15, using an instrument with polychromatic illumination (CIE D65 illuminant). The instrument shall have a 45/0 illuminating and viewing geometry. The colour coordinates shall be determined using CIE standard illuminant D65 and 2° standard observer (= CIE 1931 standard colourimetric observer). The specimen shall be measured with a single layer including any backing or lining used in its constructions and backed by a black underlay with a reflectance of less than 0,04. At least four measurements shall be carried out in four perpendicular directions and the mean value shall be given as the test result.

NOTE If the instrument is known to be either an annular or circumferential type, only one reading may be performed.

7.3 Method of determination of retroreflective photometric performance

The coefficient of retroreflection R' shall be determined in accordance with the procedure defined in CIE 54.2. Samples for measurement shall consist of two bands mounted flat and side by side as close as possible on an area of 100 mm × 100 mm.

The selection of the retroreflective band shall be made on the lowest performing 100 mm segment (e.g. presence of logos or printings or other cosmetic enhancements) with respect to the retroreflective performance. If it is determined that no such logos or printings or custom markings exist, the selection of band samples shall be made at random.

The lowest performing 100 mm segment shall be confirmed by preliminary photometric assessments. Each of the two bands shall consist of the lowest performing 100 mm segment.

R' for the sample shall be measured at two positions of the rotation angle ε, 0° and 90° and at an observation angle of 12' with an entrance angle of 5°. 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 ε = 0° can be chosen at random.

7.4 Retroreflection after exposure

7.4.1 Abrasion

The test sample shall be abraded in accordance with ISO 12947-2, using the wool fabric abradant at a pressure of 9 kPa. The specimens shall be measured after 5 000 cycles.

7.4.2 Flexing

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

7.4.3 Folding at cold temperatures

The test sample shall be exposed and folded in accordance with ISO 4675 at a temperature of (–20 ± 2) °C. Measurements shall be made after reconditioning to the atmosphere in accordance with 7.1 for at least 2 h.

7.4.4 Exposure to temperature variation

Two stripes of reflective tape of 100 mm length and the width of the tape shall be exposed continuously to a cycle of changing temperatures:

a) for 12 h at (50 ± 2) °C; immediately followed by

b) 20 h at (–30 ± 2) °C

c) conditioned for at least 2 h in accordance with 7.1.

The specimen is cut after pre-treatment to size 100 mm × 100 mm for the retroreflection test.

7.4.5 Rainfall

Samples shall be tested in accordance with Annex C.

If the material is orientation sensitive when dry, measurements shall be made at the rotation angle which gave the lowest measured performance when dry.

7.5 Ageing

7.5.1 General

When the manufacturer's instructions give a maximum number of cleaning cycles, the requirements in Table 2 for background materials and 6.2.2, 6.2.3 and 6.2.4 for retroreflective materials shall be met after the maximum number of cleaning cycles indicated by the manufacturer. If the number of cleaning cycles is not specified, the tests shall be carried out after five cleaning cycles. This shall be reflected in the information supplied by the manufacturer. The cleaning process shall be in line with the manufacturer's instructions, on the basis of standardized processes.

NOTE Manufacturers' instructions typically indicate one or several of the various methods and processes of ISO 3175-2, ISO 6330, ISO 15797 or equivalent as standardized processes for cleaning.

7.5.2 Washing

Wash in accordance with the manufacturer's instructions.

Washing shall be carried out on a readymade garment. Alternatively, for domestic laundering, three background material specimens measuring 300 mm × 250 mm shall be prepared with two stripes of

retroreflective material, each 250 mm × 50 mm, with a distance between the two stripes of 50 mm. For industrial laundering see Annex B.

The test samples shall be washed in accordance with the manufacturer's instructions.

A wash cycle consists of washing and drying.

7.5.3 Dry cleaning

Samples shall be prepared in accordance with 7.5.2.

The test sample shall be dry cleaned in accordance with the manufacturer's instructions.

8 Marking

The marking requirements defined in ISO 13688 shall be met.

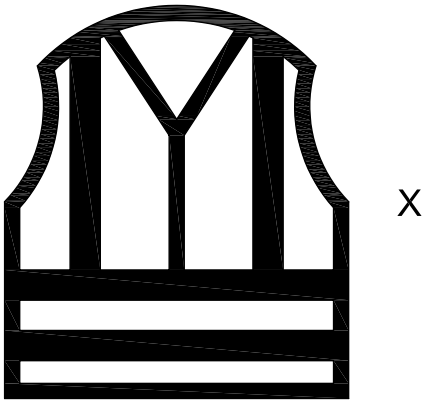


Figure 6 — Graphical symbol ISO 7000-2419: High visibility clothing

The number next to the graphical symbol (x in Figure 6) indicates the garment class in accordance with Table 1.

If a maximum number of cleaning cycles is stated in the manufacturer's instructions, this number shall be related to the component of the high visibility material (background material, retroreflective, combined-performance material) with the lowest number of washes. The maximum number of washes shall be marked on the garment's permanent label near the graphical symbol ISO 7000-2419.

9 Information supplied by the manufacturer

The requirements for information supplied by the manufacturer shall be in accordance with ISO 13688. Additionally, the following sentences shall be included in the information supplied by the manufacturer:

"The stated maximum number of cleaning cycles is not the only factor related to the lifetime of the garment. The lifetime will also depend on usage, care storage, etc."

If the colour after the Xenon test changes from one colourbox to another, this shall be mentioned in the instructions for use.

Annex A
(informative)

Information concerning risk situations

Table A.1 — Factors related to the risk level

Risk level	Factors related to the risk level[a]		Risk level	
	Vehicle speed	Type of road user		
High risk ISO 20471 class 3	> 60 km/h	Passive	High visibility	— day and night visibility — 360° (visibility from all sides) — design for form recognition — encircling the torso — quantity and quality for day and night
High risk ISO 20471 class 2	≤ 60 km/h	Passive		
High risk ISO 20471 class 1	≤ 30 km/h	Passive		— day and night visibility — 360° (visibility from all sides) — design for form recognition — quantity and quality for day and night
Medium risk	≤ 60 km/h	Active	Enhanced visibility	— day and night visibility — visibility from all sides — design for movement recognition if applicable (not necessarily encircling the torso) — quantity and quality for day and night (not necessarily ISO 20471) — more freedom in colours and design
	≤ 15 km/h	Passive		— night visibility — visibility from all sides — design for movement recognition if applicable (not necessarily encircling the torso — quantity and quality for night (not necessarily ISO 20471) — no “gadgets”
	≤ 60 km/h	Active		
Low risk	-	-	Visibility	— bright colour — piping and/or randomly designed reflective material — any quantity and quality

[a] Depending on local issues such as weather conditions, background contrast, traffic density and other factors, one of these factors may lead to a higher level.

NOTE For the definition of active road user see 3.11; for the definition of passive road user see 3.12.

Annex B
(normative)

Positioning of bands of retroreflective material on jackets for industrial wash test only

Bands of retroreflective materials measuring 250 mm × 50 mm shall be applied on a jacket as commercially available. The positioning of the bands shall be as shown in Figure B.1.

The distance between the retroreflective bands shall be at least 50 mm. The bottom of the lowest band shall be at least 50 mm above the bottom edge.

Dimensions in centimetres

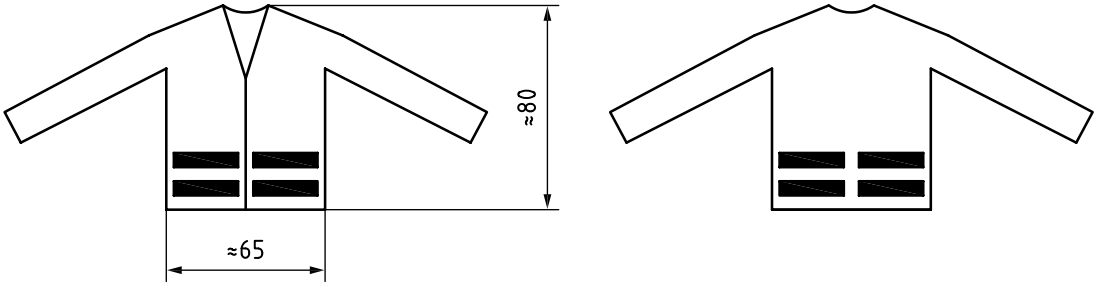


Figure B.1 — Positioning of bands of retroreflective material on jackets for industrial wash test

The specimen shall be industrially washed for the number of cycles specified on the garment care label. Neutralization shall be in accordance with the manufacturer's recommendation in order to reach the pH of 5,5 minimum. The coefficient of retroreflection R' shall be calculated as the average of measurement on the eight bands and shall fulfil the photometric requirements of 6.2.2, 6.2.3 and 6.2.4, as applicable.

Annex C
(normative)

Method of measuring wet retroreflective performance

C.1 Principle

A specimen of the material shall be mounted in a vertical plane and shall be subjected to a continuous spray of water droplets.

Measurements shall be made of the coefficient of retroreflection of the wetted surface while the spray is maintained, simulating the optical behaviour of a surface in a shower of rain.

C.2 Apparatus

A suitable apparatus for mounting the specimen in the spray of water is illustrated in Figure C.1.

The specimen (1) shall be supported on the vertical specimen holder (2) above the catch trough (3) and drain (4). The specimen holder shall be rigidly attached to the goniometer table (not shown) but shall be held away from it. The spray nozzle (5) shall be rigidly supported in a position which is fixed relative to the specimen and shall be supplied with tap water at constant but adjustable pressure through a flexible joint (6) or hose.

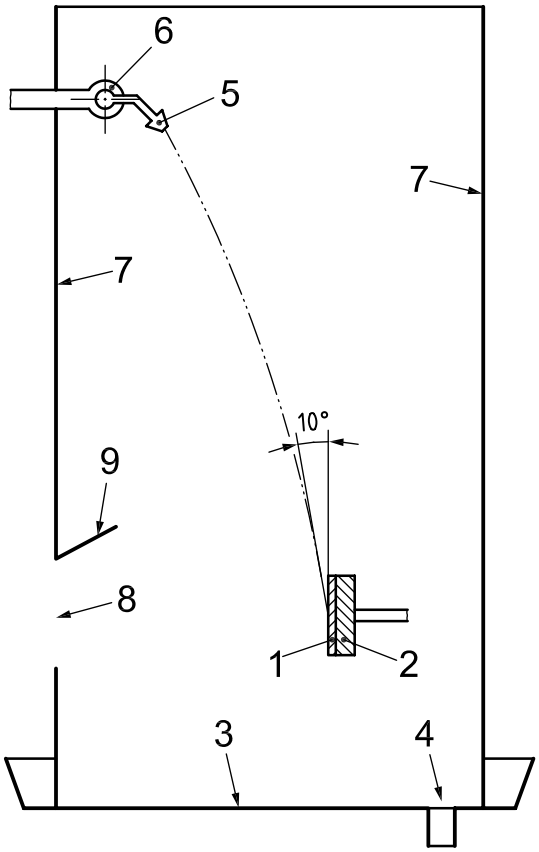
The nozzle shall be set one metre above the centre of the specimen and shall be angled so that the spray strikes the specimen at an angle of 10° to the vertical. The specimen, the specimen holder and the spray nozzle shall be enclosed in a cover (7) designed to protect the optical apparatus from water.

Preferably, the cover is made of or incorporates large areas of rigid transparent plastics material for visibility and has at least one removable panel or door for access. A square aperture (8) with side measuring 150 mm shall be provided for the light path and a gutter (9) shall protect this aperture from falling water. The region of the cover near to this aperture shall be painted matt black to reduce stray reflections. The nozzle shall be of the full cone type and shall have an orifice of diameter 1,19 mm with an appropriately designed feed pipe producing a substantially uniform solid cone spray.

C.3 Procedure

Due care shall be taken to avoid stray light.

A flat, square specimen of the material of at least 50 mm lateral length shall be mounted in a vertical plane on the vertical specimen holder so that the holder does not protrude beyond the edge of the specimen at any point. If the material is orientation sensitive when dry, as described in 6.1, it shall be mounted so that measurements can be made at the orientation which gave the lowest performance when dry. The nozzle and water supply shall be adjusted to subject the specimen to a spray of ordinary tap water such that the whole face of the specimen is within the envelope of the spray, the angle between the surface of the specimen and the water striking it is not less than 5°, and the flow rate striking the specimen is equivalent to a rainfall, in millimetres per hour, of 50/tan 10° (284 mm/h) as measured in a horizontal collector. The spray shall be maintained in a steady-state for at least 2 min before and throughout the measurement.



Key

1	specimen	6	flexible joint
2	holder	7	cover
3	catch trough	8	aperture
4	drain	9	gutter
5	spray nozzle		

Figure C.1 — Apparatus for the wet retroreflection test

Annex D
(informative)

Guidelines for the design of high visibility garments

D.1 General

Design requirements are given in 4.2. The purpose of this annex is to give additional direction on the most effective use of fluorescent and retroreflective materials in high visibility garment design. The final decision on accepting a particular design should be taken by the end user based on an appropriate risk assessment.

D.2 Visibility from all sides

The garment should be made up of high visibility material on all sides, as it is difficult to foresee from which direction the user will be approached by traffic. To ensure visibility from all sides, it is important that horizontal retroreflective bands and fluorescent materials encircle the torso, trouser legs and sleeves.

D.3 Minimizing fragmented areas

For daytime visibility, designs with larger single areas of background materials are preferable to multiple smaller but fragmented areas.

D.4 Optimized conspicuity through marking the ends of the limbs and recognition of human movement

D.4.1 It has been demonstrated that it is useful for drivers to recognize a distant object as a human being through motion cues. Retroreflective material should be present as bands on the ends of the limbs in order to best convey human activity. This concept is sometimes referred to as the biomotion effect.

D.4.2 Clear combinations of vertical and horizontal retroreflective bands provide the best visual contrast with most backgrounds. Avoid extreme diagonal elements and monolithic shapes.

D.4.3 If the user is limited to a single high visibility garment on the torso, a jacket with bands on the sleeves offers superior performance to a sleeveless vest. The use of trousers alone, even if they include the minimum areas of high visibility materials, is generally not recognized good practice.

Bibliography

[1] ISO 3175-2, *Textiles — Professional care, drycleaning and wetcleaning of fabrics and garments — Part 2: Procedure for testing performance when cleaning and finishing using tetrachloroethene*

[2] ISO 3758, *Textiles — Care labelling code using symbols*

[3] ISO 3759, *Textiles — Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change*

[4] ISO 6330, *Textiles — Domestic washing and drying procedures for textile testing*

[5] ISO 7000, *Graphical symbols for use on equipment — Registered symbols*[1)]

[6] ISO 15797, *Textiles — Industrial washing and finishing procedures for testing of workwear*

[7] ISO 30023, *Textiles — Qualification symbols for labelling workwear to be industrially laundered*

[8] EN 530, *Abrasion resistance of protective clothing material — Test methods*

[9] EN 1150, *Protective clothing — Visibility clothing for non-professional use — Test methods and requirements*

[10] EN 13356, *Visibility accessories for non-professional use — Test methods and requirements*

1) The graphical symbol collections of ISO 7000, ISO 7001 and ISO 7010 are also available on line in the ISO web store. For more information, consult http://www.iso.org/iso/home/store/publications_and_e-products/databases.htm?=

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