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IHVCA STANDARD 001-2012

Reflective Safety Clothing Standard

IHVCA – International High Visibility Clothing Association

Reflective Safety Clothing Standard

FORWARD

Reflective safety clothing must be capable of visually signaling the user's presence. The clothing shall be detectable both during the daylight conditions and at night under illumination by a vehicle's head-lights in the critical detection distance.

Clothing in most colors is visible during daylight in the critical detection distance as specified in most highway design standards. But during nighttime, for roadways either illuminated by street light or vehicle head lights, the detective distance of dark clad clothing is far shorter than the required. Proper design of the retro-reflective clothing will enhance the safety of the user.

There are high visibility safety apparel standards such as ANSI/ISEA 107-207, covering occupational clothing in the U.S., and EN471, EN 1150 in EU. But these standards are either not covering sportswear/casualwear or are driven by the properties of certain products. In lieu of minimum safety requirements, those standard starts with a specification based on the performance of certain products, and then approved and adopted by an accredited standard developer. Voting members of the developer committees often include the representatives of those manufacturers; therefore, these standards are driven by marketing of certain products instead of the safety effect.

Due to the high visibility clothing standard is safety related; the specification must be established based on published science of safety and statics of field research. This standard is specified based on the minimum required luminance at the minimum required safety detection distance, in the observation angles resemble to drivers in different sizes of vehicles.

Over specifying the coefficient of retroreflection is detrimental to the public safety, because it reduces or eliminates other important factors such as the creation of comfort and appearance. On the other hand, those reflective clothing with reflectivity below the minimum requirements will mislead people into believing they are visible while not.

This standard is developed based on published science that it can serve as a tool for the user, designer and manufacture to evaluate the performance and safety effect of the reflective clothing they are dealing with.

Contents

List of Tables

List of Figures

Notes:

(XXX000) denotes comments by ISO member countries as in reference

IHVCA Standard for Reflective Safety Clothing

1. Scope

This standard specifies requirements for reflective clothing which is capable of signaling the users presence visually intended to provide conspicuity of the user in high-risk situations under any light conditions by day and under illumination by vehicle headlights in the dark.

Performance requirements are included for color, retroreflection and minimum areas, as well as the recommended position of the materials. Performance requirements are also provided for the physical properties of the materials. Testing requirements are provided in the standard to help ensure that a minimum Class and Level of quality is maintained when items are subjected to ongoing care procedures.

2. Purpose

The reflective safety clothing is for enhancing the visibility and safety of pedestrians, cyclists, and workers at the applicable location/situation. Performance Level guidelines are identified with corresponding recommendations for selection based on risk hazards, such as complex backgrounds, type of vehicular traffic, and speeds encountered.

3. Compliance

Manufacturers of high visibility safety clothing, apparel, and headwear shall verify that the clothing and the material used in manufacturing the clothing comply with this standard. All certificates and test reports that verify the performance of materials used in manufacturing the finished item shall be retained by the manufacturer and be made available to ensure that all items labeled as meeting this standard have completed all of the testing and certification required by the standard. Manufacturers of the finished items shall certify or self-certify compliance that all garment design requirements are achieved to meet requirements of Section 7 in their entirety. Appendix E contains sample certificates to be used for self-certification of the reflective safety clothing

4. Definitions

Accredited Laboratory: A laboratory having a certificate of accreditation meeting the requirements ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories* (or other equivalent standard) for the collection and analysis of data within the parameters of this standard.

Area Performance Reflective Material: Reflective system in form or letters, numbers, logos, art works, or any graphic patterns covers part (less than 100%) of a background material.

Background Material: Colored material intended to be used in High Visibility Clothing, but not intended to comply with the requirements of this standard for retroreflective material.

Candela (cd): the SI unit of **luminous intensity**, that is, the power emitted by a light source (e.g. from a vehicle's headlamps) in a particular direction.

Certify (background and retroreflective material): To obtain compliance certification documents based on testing from an independent, third-party accredited laboratory to verify performance requirements as specified in this standard.

Certify (finished products): To obtain certification from the manufacturer for finished products to fully comply with IHVCA reflective safety Clothing Certificate. (Appendix F)

Coefficient of Luminous Intensity (R_I): is the ratio of the luminous intensity (I) of the reflector in the

direction of the observer to the illuminance (E), expressed in candelas per lux ($cd.lx^{-1}$)

Coefficient of Retroreflection (R_A) (Reflectivity Index or Retro-reflective Photometric Performance): of a planar reflecting surface is the ratio of the coefficient of luminous intensity (R_I) of a planar reflecting surface to its visible reflective area (A_I) expressed in candelas per lux per square meter ($cd.lx^{-1}.m^{-2}$). $R_A = R_I/A_I$.

Area-performance material: Either a retroreflective material that is also a fluorescent material, or a retroreflective material covers part of background material. Area performance materials can be counted toward the minimum area requirements for background material specified in Table 1 and Table 2.

Combined Performance Retroreflective Material: Retroreflective Material which contains a colored reflective system or mix in with a colored background material, so that the material has both reflective function and color function.

Conspicuity: The characteristics of an object influencing the probability that it will come to the attention of an observer at critical observation distance.

Entrance Angle: The angle between the incoming light and the line perpendicular to the plane of the reflective fabric surface.

Flame resistance: The property of a material whereby flaming combustion is prevented, terminated, delayed or inhibited following application of a flaming or non-flaming source of ignition with or without subsequent removal of the ignition source.

Fluorescent material: Material that instantaneously emits optical radiation within the visible range at wavelengths longer than absorbed and for which emission ceases upon removal of the source of irradiation. These materials enhance daytime visibility, especially during dawn and dusk.

Reflective Safety Clothing: Personal apparel containing retroreflective and/or colored background elements to be visible by vehicle drivers in critical detection distance and intended to be worn and covered a part of human body .

Illuminance (E), the amount of light striking a surface measured in lux (lx).

Luminance: light retro-reflected back to an observer, seen as "brightness".

Luminous Intensity (I): is the luminance measured in candelas per square meter ($cd.m^{-2}$)

Observation Angle: The angle between the line from the light source to reflective fabric and the line from the reflective fabric to the driver's eyes.

Photometric Performance Level: The effectiveness of retroreflective material in returning light to its source, expressed in Table 1 and Table 2, and measured in terms of coefficient of retroreflection.
NOTE: The photometric terms and definitions used in this document are defined in ASTM E284 and ASTM E808.

Retroreflective Material: Material that is a retroreflector and is intended to comply with the requirements of this standard for reflective safety clothing.

Reflective Area (A): The actual area of reflective material measured by spreading the reflective material on a smooth flat plane.

Shoulder Area: The shoulder-area is part of the torso of human body, and upper part of arms lies 10 cm (4 inches) below the top of shoulder line and 15 cm (6 inches) from the top edge of the shoulder.

Sleeve Area: Starting at the end of the shoulder area to the top of cuff, half of the width of the sleeve.

Solid Performance Reflective Material: A material is fully covered with a retro-reflective system in compliance or non-compliance with background material color.

Trousers: An outer garment, covering the lower body from the waist to the ankles and divided into separate coverings for the legs: also called pants.

Measured Planar Area (A_M): The area facing the observer, the size is the actual area measured spreading flat.

Planar Area (A_I): The area facing the observer, the size is equivalent to a plane perpendicular to the direction of observer.

Water repellent: The characteristic of a fabric to resist wetting.
Water resistant: The characteristic of fabric to resist wetting and penetration by water.

Waterproof: The resistance of a fabric to the penetration of water under pressure or spaying.

5. Types, Levels, Classes and Colors

5.1 Garment Types

Reflective safety clothing includes, but is not limited to ponchos, vests, waistcoats, harness, jackets, trousers, coveralls, and headgears, etc.

5.2 Visibility Performance Levels

Three Levels of performance in each garment are defined based on different minimum areas of retroreflective, fluorescent and/or area performance and/or other color background materials. This involves with consideration of the factors which may affect an observer's ability to detect that a person is present. Each of these performance Levels will provide the observer the needs both to perceive and to recognize the wearer early and then needs to be able to take appropriate avoidance action. Users should select the required Level of Performance based on location/situation of the risk environment where the protection afforded by clothing to this standard is required.

A documented hazard report for the location/situation of application and the activity of the potential user is suggested to determine the appropriate performance level and class required. Each type of reflective safety clothing is classified based on the performance level of conspicuity as in Table 1 or Table 2, and the class of the garment as defined in Section 5.4.

5.2.1 Performance Level 1 is for pedestrians or pedestrian workers used in but not limited to urban street, airport, or parking lots where predominant vehicles are passenger cars, pickups, vans, and small trucks, as defined as Group 1 vehicles in Appendix A.

5.2.2 Performance Level 2 is for cyclists traveling or professionals working on rural roadways, where the traffic includes passenger cars, pickups, vans, small trucks, full size trucks, and buses, as defined as Group 1 and 2 vehicles in Appendix A. Photometric performance of Level 2 must also meet all requirements of Level 1.

5.2.3 Performance Level 3 is for motor vehicle operators traveling on or professional working on highways with all kinds of vehicles as defined as Group 1, 2 and 3 vehicles in Appendix A. Photometric performance of Level 3 must also meets all requirements of Level 2.

5.3 Retroreflective performance requirements

The coefficient of retroreflection for all retroreflective performance material shall be measured after the number of washing cycles as claimed to users on the label.

5.3.1 Measurement

Measurements shall be made by the method described in Section7.3. When measured at the two rotation angles ε1= 0° and ε2 = 90° materials having coefficients of retroreflection that differ by more than 15% are defined as orientation sensitive. The least average coefficient of retroreflection R_A value of the orientation sensitive material shall comply with the minimum requirements for the coefficient of retroreflection stated in Table 1 or Table 2. Entrance angles shall be tested at 9^o, 27^o, and 50^o. Observation angles shall be tested at 12', 22', and 34'. The minimum required coefficient of retroreflection R_A, shall be equal or above the average R_A of the retroreflective material. The required R_A must meets the requirement that the luminous intensity R_I (= A_I × R_A) > 0.3 $cd.lx^{-1}$ in all required viewing angles.

5.3.2 Retroreflective Materials

The coefficient of Retroreflection of the Retroreflective materials shall comply with the requirements of Table 1.

5.3.3 Orientation of Retroreflective Material

When measured at the two rotation angles ε1= 0° and ε2 = 90° materials having coefficients of retroreflection that differ by more than 15 % are defined as orientation sensitive. The least average coefficient of retroreflection R_A value of the orientation sensitive material shall comply with the minimum requirements for the coefficient of retroreflection stated in Table 1. NOTE: The garment should be made up of reflective material visible on all sides.

5.3.4 The Use of Retroreflective Material

Either solid performance or area performance or the combination of the both of the above material may incorporated in clothing design, subject to the required R_A must meet the requirement that the luminous intensity R_I (= A_I × R_A) > 0.3 $cd.lx^{-1}$ in all required viewing angles.

Table 1. Level of Service based on Minimum Coefficient of Retroreflection R_A in cd/(lx · m²) and Corresponding Planar Area of Retroreflective Material

User Level Location Observation Angle	Entrance Angle			Min Avg R_A	Req'd Planer Area A_I $cm^2/(in^2)$
	9°	27°	50°		
Level 1 Urban Street 12'	R_A	R_A	R_A	13	270/ (42)
Level 2 Rural Road 22'	R_A	R_A	R_A	10	333/ (52)
Level 3 Highway 34'	R_A	R_A	R_A	6	588/ (91)

Notes:

1. Each of the 3 entrance angles represents 30% of the reflective material. The last 10% of reflective material with high entrance angles are assumed to be zero or considered as an extra safety factor.
2. A_I value is suggested based on average R_A value; A_I is adjustable based on R_A reading as computed in Appendix B.
3. Testing sample shall be pre washed based on designed washing method and washing cycles as claimed.
4. The Corresponding Required Planer area A_I decreased as the Average R_A increased.

5.4 Visibility Performance Classes

Four Classes of performance are defined based on different use of the reflective safety clothing. This will involve consideration of the activity which may affect an observer's ability to detect that the user is present. Each Class will provide the observer the ability to perceive and recognize the wearer early, that the observer is able to take appropriate avoidance action. Users should select the Class of Application based on the activity the user is partaking in, so that the protection offered by the

clothing provides sufficient protection.

An activity analysis for the application is suggested to determine the appropriate Performance Class. Each type of reflective safety clothing is classified based on the Level of conspicuity as in section 5.3.4 and the Class of application described here below:

Trousers or pants with reflective panels are assumed to be worn in combination with other tops. The reflective and background areas could be counted in front, side, and rear views. The reflective area on reflective headgears is considered to have the same visibility effect as the shoulder area.

The actual Measured Area (A_M) is larger than the visual Planar Area (A_P); the conversion factor is tabulated in Table 3 and Appendix C.

5.4.1 Performance Class1 is for pedestrians or pedestrian workers who are normally standing in upright position, alert to incoming vehicles, and need to be visible by vehicles from the front and back directions. The minimum required visual Planar Area (A_I) in each of the front and back directions shall be no less than A_I what is stated in Table 1.

5.4.2 Performance Class 2 is for pedestrians or pedestrian workers, who are not always alert to incoming vehicles, who need to bend down facing incoming traffic, and need to visible by vehicles from the front, back, and top directions. The minimum required visual Planar Area (A_I) in each of the front, back, and top direction directions shall be no less than A_I what is stated in Table 1 or Table 2.

5.4.3 Performance Class 3 is for pedestrians or pedestrian workers who need to be visible in 360^o horizontally and 180^o vertically, who need to be visible by incoming traffic all the times, and seldom bend over. When these users bend over, they will be alert to incoming traffic and bend facing towards the traffic so that they are visible from the top of their shoulders. The garment should be made up of reflective material visible on all sides, as it is difficult to foresee from which direction the user will be approached by traffic. The minimum required visual Planar Area (A_I) in each of the front, back, side, and top directions shall be no less than A_I what is stated in Table 1.

5.4.4 Performance Class 4 is for cyclists or professionals working, who need to bend down frequently, requiring to be visible by oncoming traffic at all times from 360^o horizontally and 360^o vertically. The garment should be made up of reflective material visible from all viewing direction, as it is difficult to foresee from which direction the user will be approached by traffic in all directions.

5.4.5 Reflective materials on different parts of the clothing are visible in a corresponding direction. A percentage of the measured reflective area is crediting to the visual Planar Area in direction as stated in Table 2.

Table 2. Visual Planar Area (A_p) observable in different observation direction in percentage of Measured Area (A_M)

Reflective Area	Observation Direction				
	Font	Back	Side	Top	Rear
Shoulder/Hat	32%	32%	20%	64%	0%
Sleeve	32%	32%	32%	26%	0%
Front	64%	0%	8%	5%	0%
Back	0%	64%	8%	5%	5%
Rear	0%	64%	16%	5%	64%

Note: See Figure 3,4, for the Terminologies of Reflective Area and Observation Direction

5.5 Color-Performance requirement for Background Material, Non-Fluorescent material and Area-Performance material

The prevailing ambient background, in which the subject high visibility clothing is applying to, shall be taken into consideration; and the color providing

the preferred contrast shall be selected. If the color changes from one color box to another, this shall be mentioned in the instructions for use.

5.5.1 Color Selection

5.5.1.1 The color of the background material shall stand out from the urban environment where the high visibility warning clothing is applicable.

5.5.1.2 For the clothing fluorescent color is selected, the chromaticity shall lie within one of the chromaticity coordinates defined in Table 4 and also the luminance factor and the background material area shall exceed the corresponding minimum in Table 3.

Table 3 — Color requirements for background and area performance

Color	Chromaticity coordinates x y		Minimum Luminance factor ßmin	Minimum Area $cm^2/(in^2)$
Fluorescent lime-yellow	0.358 0.329 0.398 0.460	0.638 0.528 0.452 0.540	0.70	5,000 / (775)
Fluorescent orange-red	0.483 0.593 0.690 0.535	0.384 0.408 0.310 0.319	0.25	5,000 / (775)

6. Design

Each type of risk related reflective safety clothing shall be detectable by vehicle drivers, at the critical detection distance at the applicable location/situation and the specified viewing angles in used condition during day and night. Each Level of reflective safety clothing shall have the minimum areas of materials incorporated into the garment in accordance with Table 1 or Table 2 for night time visibility. The garment should be made up of reflective material visible from on all sides, as in section 5.4. Garments of each Level and Class of performance shall have retroreflective material with minimum Luminous Intensity (I) of 0.3 $cd.lx^{-1}$ (300 $mcd.lx^{-1}$) in such a manner to provide visibility of the wearer at all viewing angles the clothing is designed for.

6.1 The materials and components of the reflective safety clothing shall not be known to adversely affect the wearer.

6.2 The reflective safety clothing shall offer the wearer the best possible degree of comfort that is consistent with the provision of adequate protection.

6.3 Parts of the reflective safety clothing that come into contact with the end user shall be free of roughness, sharp edges and projections that could cause irritation or injuries.

6.4 Reflective safety clothing shall be fitted to correct positioning on the user and should ensure that it remains in place for the expected period of use, anticipating environmental factors as well as movements the wearer could adopt during the course of work.

6.5 Color of material used for reflective safety clothing shall be designed so that the wearer is visible in critical detective distance day and night. When using two or more background materials the total area usable regardless of color shall be measured. It is encouraged that high luminance colors include fluorescent colors to distinguish the colors of intended environments. Other colors in the garment visible at the critical detection distance are acceptable, as long as the colors do not resemble highway pavement, traffic signs, road liners, snow, or any other color found in the environment of use. For night time design, color correction factor is not applicable.

6.6 The dimension of reflective safety clothing shall be designed to fit body with the proper size. The actually visible area when wearing the garment shall be carried out with a subject within the size range of the garment. This test is necessary to check the

visible surfaces when garments are worn.

6.7 The dimensional change of the garment shall not exceed ± 4% in length and ± 2% in width for woven fabrics. The dimensional change of background material shall not exceed ± 7% in length and ± 5% in width for knit fabrics.

7. Testing Method I - Reflective Material Properties

7.1 Sampling and conditioning

a) Specimens: Samples for testing shall be taken from original garment or from material or materials as used in the finished garment

b) Specimens preparation: Specimens must be washed the number of cycles according to the care label as specified in 7.5.1.5 and 7.5.1.6 prior to forgoing testing.

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

d) Conditioning of specimens: 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. For tropical or subtropical countries, the specimens shall be conditioned for at least 24 h and tested at (27 ± 2) °C and (65 ± 5) % relative humidity.

7.2 Determination of Color

The color shall be measured in accordance with the procedures defined in CIE 15, using an instrument with polychromatic illumination (D85 simulator). The instrument shall have (45^oa:0^o) or (0^o:45^oa) illuminating and viewing geometry as defined in CIE 15. The quality of irradiating instrument light source should be more than category BC (CIELAB) estimated by ISO 23603/CIE S012 method. The color coordinates shall be determined using CIE standard illuminant D65 and 2^o standard observer. The specimen shall be measured with a single layer including any backing or lining used in its constructions and backing by a black underlay with a reflectance of less than 0.04.

At least eight (8) measurements shall be carried out at 45° incremental steps about the measurement axis and the mean value shall be given as test result. Note: If the instrument is known to be either of the annular or circumferential type then only a single measurement may be required**.**

7.2.1 Color Fastness to light of background material and all non-fluorescent material layers after test exposure

The color after exposure shall be within the areas defined by the coordinates in Table 3 for background materials and area performance materials and its luminance factor shall exceed the minimum value for the luminance factor of the color that is obtained on exposure to xenon light e. g. a fluorescent red is acceptable if after exposure to xenon light its color-co-ordinates 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 according to ISO 105-B02:1994, method 3. 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 grey scale. If the color can change from one colorbox to another, this shall be mentioned in the instructions for use.
The color fastness (dry) when determined in accordance with ISO 105-A02 shall be at least step 4 of the grey scale. The test shall be conducted in accordance with ISO 105-X12.

7.2.2 Color Fastness to Perspiration

The color fastness when determined in accordance with ISO 105-A02 shall be at least step 4 of the grey scale for the color change of the specimen; and when

determined in accordance with ISO 105-A03 at least step 3 with respect to staining. The test shall be conducted in accordance with ISO 105-E04.

7.2.3 Color Fastness - when laundered, dry cleaned, hypochlorite bleached and hot pressed

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

7.3 Determination of Retroreflective Photometric Performance

The coefficient of retroreflection R_A shall be determined in accordance with the procedure defined in CIE publication No. 54.2. Measurements shall be made on sample size of 100 mm × 100 mm or two bands of 50 mm × 100 mm mounted flat and side by side as close as possible on an area of 100 mm x 100 mm. The selection of the retro-reflective band shall be made on the poorest performing 10 mm segment with respect to the retro-reflective performance. The poorest performing 10 mm segment shall be determined by preliminary photometric assessments. Each sample shall consist of the poorest performing 10 cm segment. R_A for the sample shall be measured at two positions of the rotation angle ε, 0° and 90° and at an observation angles as described in Table 1 and Table 2. 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.

7.3.1 Service Life Guidelines

All garments have a limited lifetime. The protective measure of the retroreflective performance of reflective safety clothing decreases after a certain amount of washing cycles. Depending on the laundering methods, the type of environment, and the period of time exposed to the environment, the manufacturer is responsible for defining the allowable washing cycles to ensure the performance of the subject garment meets the minimum required visibility performance Class during the life time of the garment, according to Table 1 and Table 2.

7.3.2 Testing of Retroreflective Photometric Performance

All the specimens shall be conditioned for at least 24 hours at 20 ± 2°C (68 ± 2°F) 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.

7.3.3 Retroreflection Property

The Coefficient of Retroreflection of solid performance and area performance retroreflective materials shall meet the minimum as listed in Table 1 or Table 2 after the tests below.

7.3.4 Flexing

The test sample shall be flexed in accordance with ISO 7854:1997, *Rubber- or plastics-coated fabrics - Determination of resistance to damage by flexing (dynamic method), Method A.* The specimens shall be measured after 7,500 cycles.

7.3.5 Folding at Cold Temperatures

The test sample shall be exposed and folded in accordance with ISO 4675:1990, *Rubber or plastic coated fabric - Low-temperature bend test at a temperature of -20 ± 1 °C (-2 ± 1 °F).* Measurements shall be made after reconditioning to the atmosphere for at least 2 hours.

7.3.6 Exposure to Temperature Variation

Specimens of the size of 180 mm x 30 mm (7.09 in. x 1.18 in.) shall be exposed continuously to a cycle of changing temperatures: for 12 hours at 50 ± 2°C (122± 2°F) immediately followed by 20 hours at -30 ± 2°C (-20 ± 2°F); measurement shall be made after conditioning for at least 2 hours.

7.3.7 Abrasion Resistance

The test sample shall be abraded in accordance with EN 530:1994, *Abrasion resistance of protective clothing material*, Method 2, using a woolen fabric abrasion. The specimens shall be measured after 5,000 cycles, using a weight of 9kPa.

7.3.8 Washing According to Care Label

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 5.2, after a minimum of five washing cycles. The test samples shall be washed in accordance with ISO 6330:2000, *Textiles – Domestic washing and drying procedures for textile testing*, *Method 2A.* The specified wash cycle shall be applied to the test sample for the number of times stated in the label. After the last wash cycle the samples shall be flat dried, stress free, at 50 ± 5°C (122 ± 5°F), according to ISO 2330 C.

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7.3.9 Dry-Cleaning Optional According to Care Label

Manufacturers may opt to have dry-cleaning property. Samples are prepared in accordance with Section 8. The test sample shall be dry cleaned in accordance with ISO 3175:1998, Method 9.1, *Textiles - Determination of dimensional change on dry cleaning in perchlorethylene* - Machine method, or equivalent. The test sample shall be cleaned for the number of cleaning cycles stated in the care label.

8. Testing Method II – Fundamental Property

All outer shell material for reflective safety clothing shall meet the following requirements except otherwise specified in the standards as listed in section 7 are adopted in full or in part.

8.1. Mechanical Properties for Outer-Shell Materials

8. 1.1 Bursting Strength of Knitted Materials and Other Nonwoven Constructions

The minimum bursting strength shall be 267 N (60 lbs) tested in accordance with ASTM D3787-01, Standard. Test Method for Bursting Strength of Knitted Goods - Constant-Rate-of-Traverse (CRT) Ball Burst Test. Each specimen shall be at least 125 mm (5 in) square, or a circle 125 mm (5 in) in diameter. Or the minimum bursting strength shall be **100** k.Pa. tested in accordance with ISO 13938-1 or ISO 13938-2 using test area of **50 cm²** Determine time to burst shall be (20±5)s.

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

Outer shell materials for reflective risk-related clothing shall be tested in accordance with ASTM D1424-96, *Standard Test Method for Tearing Strength of Fabrics by Falling-Pendulum Type (Elmendorf) Apparatus* at a minimum requirement of 13 N (1326 grams) in both directions. Or according to ISO 4674-1:2003, method A, and have a minimum of 25 N.

8.1.3 Tensile Strength of Woven Material (Uncoated, Coated or Laminate)

The tensile strength in weft and warp direction shall fulfill the following requirement: – Tensile strength (in N) shall be ≥ 400 N (90 lbf); – Tensile strength shall be tested in accordance with EN 343 standard uses ISO 4674-1:1977 version or ASTM D1424. For materials with an elongation of more than 50 % this requirement is not applicable, the material shall be tested according to 8.1.1. For garments which offer protection against rain according EN 343 use the classification according EN 343. 5.6.2

8.1.4 Dimensional Change of Background Material

a. The dimensional change of background material shall not exceed ± 4% in length and ± 2% in width

for woven fabrics. The dimensional change of background material shall not exceed ± 7% in length and ± 5% in width for knit fabrics.

b. Preparation of the specimen material shall be done in accordance with ASTM D1776 – 90 *Standard Practice for Conditioning Textiles for Testing*.

c. As directed by the care label, dimensional change shall be evaluated by preparing one sample per test method in accordance with Section 9.3 and subjecting the sample to five cleaning cycles in accordance with the following applicable standards:
-- AATCC 135-2000 (3) (III) (A) (iii) *Textiles -Test for dimensional changes – Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*;

-- AATCC 158-1995, Textiles - *Test for Dimensional changes - Dimensional Changes on Dry-cleaning in Perchlorethylene: Machine Method*

-- AATCC 96-1999 (IIIc) (A) and/or (E) *Textiles - Tests for dimensional changes – Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics Except Wool*

8.2. Color Fastness

Preparation of the specimen material shall be done in accordance with ASTM D1776 –90, *Standard Practice for Conditioning Textiles for Testing*, according to the care recommendation of the garment. The enclosed carbon arc apparatus is also described in JIS L 0842 ASTM G 1155 and AATCC Test Method 16-2001, Textiles - Colorfastness to Light (Test Option 3) - Xenon Arc Lamp, Continuous Light. Expose the materials to 40 AATCC Fading Units. The light fastness of the test sample shall be determined in accordance with AATCC 16-1998, Textiles – Colorfastness to Light (Test Option 3) – Xenon Arc Lamp, Continuous Light. Expose the materials to 40 AATCC Fading Units (170 KJ/m2@420nm)

8.2.1 Colorfastness to Crocking

The colorfastness to crocking both dry and wet shall be at least a grade 3.0 by the Gray Scale for Staining in accordance with AATCC 8-2007, *Textiles - Tests for colorfastness – Colorfastness to Crocking*. The colorfastness (dry) when determined in accordance with ISO 105-A02 shall be at least step 4 of the grey scale. The test shall be conducted in accordance with ISO 105-X12.
The colorfastness to crocking both dry and wet shall be at least a grade 3.0 by the Gray Scale for Staining in accordance with AATCC 8-2007, *Textiles - Tests for colorfastness - Colorfastness to Crocking.* The colorfastness (dry) when determined in accordance with ISO 105-A02 shall be at least step 4 of the grey scale. The test shall be conducted in accordance with ISO 105-X12.

8.2.2. Colorfastness to Perspiration

The color fastness to perspiration shall be at least grade 4.0 by the Gray Scale for Color Change and at least a grade 3.0 by the Gray Scale for Staining in accordance with AATCC 15-2002, *Textiles - Tests for colorfastness - colorfastness to Perspiration.* The color fastness when determined in accordance with ISO 105-A02 shall be at least step 4 of the grey scale for the color change of the specimen; and when determined in accordance with ISO 105-A03 at least ` step 3 with respect to staining. The test shall be conducted in accordance with ISO 105-E04. Requirement to change in color shade applies only to fluorescent colors

8.2.3 Colorfastness — When Laundered, Dry-cleaned, Hypochlorite Bleached and Hot Pressed

When the care label requirements are as specified in Table 1 and Table 2 the colorfastness shall be determined in accordance with the performance requirements and test methods stated in Table 4. Specimens shall be line dried at a temperature not exceeding 60^{o} C (140 ^{o} F) with parts in contact only at the lines of stitching. Hot-pressing: Samples shall be pressed in the dry condition only. The hot-

pressing shall be tested in accordance with the ironing instructions on the garment care label, where
(.) is a temperature of 110 ± 2 °C (230 ± 2 °F)
(..) is 150 ± 2 °C (302 ± 2 °F) and
(...) is 200 ± 2 °C (392 ± 2 °F)
The colorfastness shall be determined in accordance with ISO 105-A02 for change in color and with ISO 105-A03 for staining with the performance requirements and test methods of Table 4.

Table 4. Colorfastness

Care process	Fastness, grade of the gray scale, at least	Test method
Domestic machine laundry	Color change: Grade 4; Staining: Grade 3.0	Modified AATCC 61-1996 to use 105 F or ISO 105-C06a
Commercial laundry	Color change: Grade 4 Staining: Grade 4	ISO 105-C06, E 2S
Dry-cleaning	Color change: Grade 4	AATCC 132-1998 ISO 105-N01
Hypochlorite bleaching Domestic Commercial	Color change: Grade 4 Staining: Grade: 3.0	AATCC 61-2001 or ISO 105-N01
Hot-pressing	Color change: Grade 4 Staining: Grade 3.0	AATCC 133-1999 or ISO 105-X11
Domestic hand wash	Color change & Staining: Grade 3	AATCC 107 -2002

Note: Care recommendations according to ISO 3758

8.3 Optional Property

Reflective safety clothing may include but not limited to the following property if so specified on the label.

8.3.1 Flammability

Manufacturers may opt to have reflective garments evaluated for flame resistance and marked accordingly. The flammability shall meet that of one of the following standards:
EN 533 1997, Protective Clothing – Protection against heat and Flame – Limited flame spread materials and material assembles

- ISO 11611:*2007 Protective clothing for use in welding and allied process*
- ISO 11613:*1999 Protective clothing for firefighters –Laboratory test methods and performance requirements*
- NFPA701 2004, *Standard Method of Fire Tests for Flame Propagation of Textile and Films*
- NFPA 1971, *Standard on Protective Ensemble for Structural and Proximity Fire Fighting*
- NFPA 1977, *Standard on Protective Clothing and Equipment for Wild land Fire Fighting*
- NFPA 1999, Standard on Protective Clothing for Emergency Medical Operation
- NFPA 2112, *Standard on Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire*

8.3.2 Water Repellency

Reflective safety apparel which is to be marketed as providing Water Repellency Protection shall be tested in accordance with AATCC 22-2005, *Textiles - Tests for water resistance – Water Repellency: Spray Test* with an original requirement of 90 and after five laundry cycles a requirement of 70.

8.3.3 Water Resistance

Reflective safety apparel which is to be marketed as providing Water Resistance Protection shall be tested initially and after five launderings, in accordance with AATCC 35-2006, *Textiles - Tests for water resistance - Water Resistance: 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 Class 1.

8.3.4 Water Proof

Reflective safety apparel which is to be marketed as providing Water Proof Protection shall be tested in accordance with AATCC 127-2003, *Textiles - Tests for water resistance – Water Resistance: Hydrostatic Pressure Test* testing with water to the face side with a minimum requirement of 200 cm. (78.74 in.) originally and after five launderings. 5.6.1 For garments which offer protection against rain according EN 343 use the classification according EN 343. 5.6.2

8.3.5 Water Vapor Permeability Classified as Breathable

Reflective safety apparel which is marketed as waterproof and classified as breathable, shall be tested in accordance with ASTM E96-05, *Textiles - Standard Test Methods for Water Vapor Transmission of Materials,* Procedure B - (upright for microporous) with a minimum requirement not lower than 600 g/m^2/24 hours; or Procedure BW- (inverted for hydrophilic with a minimum requirement not lower than 3,600 g/m^2/24 hours.

8.3.6 Ergonomics

In additional to visible, the reflective safety clothing should be in favorable appearance, comfortable and durable that the users are willing to wear it to be protected. The ergonomic requirements of ISO 13688, Clause 4.3 Design and Clause 4.4 Comfort shall be met.

9. Care Labeling and Marking

Washing or cleaning instructions shall be indicated in accordance with ASTM D5489 – 01a, *Standard Guide for Care Symbols for Care Instructions on Textile Products*, as relevant. The maximum number of processes for the finished item shall be stated after 'maximum' next to the care labeling (Example: max 25 times).

9.1 General Marking

Each piece of apparel and headwear shall be marked. For clothing complying with this standard, the marking shall be: IHVCA 2012, Level X, and Class X on the product itself or on labels attached to the product. For clothing adopting with other standards in whole or in part, the marking of the standard or the section of the standard shall be added under the above mark: i.e. IHVCA 2012, section X, permanently affixed so as to be visible and legible, durable for the appropriate number of cleaning processes.

NOTE: The use of numbers not smaller than 2 mm (0.08 in.) and pictograms not smaller than 10 mm (0.39 in.) is recommended. Numbers and pictograms are recommended to be black on white background.

9.2 Specific Marking

All the marking requirements defined in EN 340 shall be met. (EN471) The marking shall include the following information:

(a) Name, trademark or other means of identification of the manufacturer or authorized representative;
(b) Designation of the product performance Level and performance Class;
(c) Size designation;
(d) Level of this product under IHVCA 2012 standard;
(e) The maximum number of washing cycle the product is designed for;
(f) Number of specific method used to evaluate flame resistance, if applicable.

9.3 Care Label Test Method

As directed by the care label, the dimensional changes shall be evaluated by preparing one sample per test method in accordance with Section 7.3.2 and subjecting the sample to five cleaning cycles in accordance with the following applicable standards:

- AATCC 135-2000 (3) (III) (A) (iii) *Textiles - Test for dimensional changes – Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*;
- *AATCC 158-1995, Textiles - Test for dimensional changes - Dimensional Changes on Dry-cleaning in Perchlorethylene: Machine Method*
- AATCC 96-1999 (IIIc) (A) and/or (E) *Textiles - Tests for dimensional changes – Dimensional hangers in Commercial Laundering of Woven and Knitted Fabrics Except Wool*

10. Instructions for use

Protective clothing shall be supplied to the customer with information written at least in the official language(s) of the state of destination. All information shall be unambiguous. The following minimum information shall be given:

(a) fitting; how to put on and take off, if relevant;
(b) necessary warnings of misuse;
(c) limitations on use;
(d) storage; how to store and maintain correctly, with maximum periods between maintenance checks;
(e) maintenance and cleaning; how to clean or decontaminate correctly, with complete washing or dry cleaning instructions;
(f) the number of cleaning processes without impairment of its performance Class.

11. Information to be supplied by the Manufacturer

The requirements of EN 340 shall be met. Retroreflective materials and background materials shall be certified by 3rd party ISO/IEC 17025:2005 accredited laboratory. The following report and certificate shall be supplied by the manufacturer.

11.1 Reports for each Sample Tested:

The report shall include the following information:

(a) Performance Level of the sample shall be reported. When the sample meets more than one performance Level, the highest Level shall be reported. The required A_I for the subject Level shall be claimed.
(b) The adjusted A_I viewing in various directions including front, back, sides, top and rear shall be computed and listed in the report.
(c) Performance Class of the sample shall be reported. Each of the adjusted A_I as described in 8.1(b) shall be recorded and compared with the required A_I as described in 8.1(a).
(d) The adjusted A_I viewing in various directions including front, back, sides, top and rear shall be computed and listed in Table D-1.(see Appendix D)
(e) Record “pass” for those the adjusted A_I more than or equal to the required A_I.
(f) Record “fail” for those the adjusted A_I less than the required A_I.

11.2 Certification for each Sample Tested:

For a sample that meets all of the requirements, a certification of the reflective safety clothing based on IHVCA Reflective Safety Clothing Standard shall be issued. A certification shall include the following information: model number, brand name (if any), manufacturer, performance Level, performance Class, background material area, certification company’s name, address, signature, name, seal and date of certification. A sample of the certificate can be found in Appendix F.

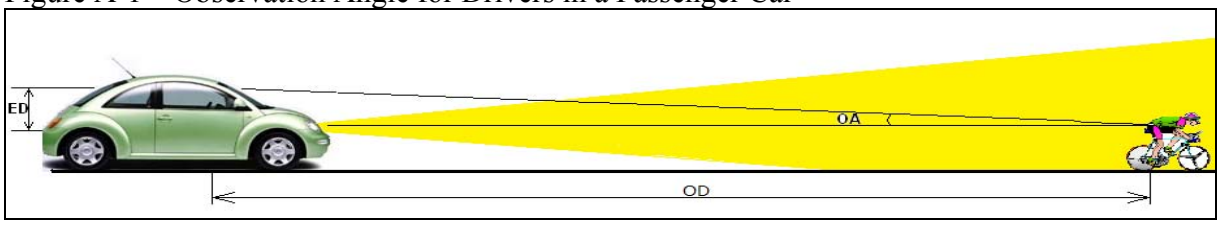
Appendix A

Observation Angle and Performance Level

Observation angles are the angle between the line from the light source to the subject reflective material and the line from the reflective material to the driver's eyes. The observation angle (OA) varies depending on the observation distance (OD) and the distance from the driver's eye Class to the vehicles head lamps (ED).

$$OA = \tan^{-1} (ED/OD)$$

Figure A-1 – Observation Angle for Drivers in a Passenger Car



The distance from driver's eye to vehicle's head lamp, ED, varies. For most passenger cars, the average ED is 0.5 meter, as shown in two vehicles in Figure 2.

Figure A-2 – Group/Level 1 Vehicles, Car and Truck with Eye to Headlamp Distance about 0.5m

The distance from driver's eye to vehicle's head lamp, ED, varies. For most truck and bus, the average ED is 1.2 meter, as shown in two vehicles in Figure 3.

Figure A-3 – Group/Level 2 Vehicles, Truck and Bus with Eye to Head Lamp Distance about 1.2m

The head lamp of extreme large-size commercial vehicles could be 2 meters lower from the top driver's seat as shown in Figure 4.

Figure A-4 – Group/Level 3 Vehicles, Truck and Bus with Eye to Headlamp Distance about 2m

The purpose of selecting a group of observation angles for testing reflective materials in the laboratory is to make sure the reflective material may be observable at the critical detectable distance by drivers on most kind of vehicles. At a critical detecting distance of 140 meters, a car driver can see the reflected light with observation angle of 12' only, a regular truck or bus driver can see 22' only and for special truck and bus with the headlight really low, the driver can see that of 34' only. The Observation Angles for each type of vehicle are computed as follows:

For a critical detecting distance of 140 meters,

$$OA1 = \tan^{-1}(0.5/140) = 12'$$
$$OA2 = \tan^{-1}(0.9/140) = 22'$$
$$OA3 = \tan^{-1}(1.5/140) = 34'$$

Observation angles corresponding to distances less than the critical detecting distance are also important for the driver to continue to see the pedestrian. However, as the observation distance is reduced there is a corresponding to the fourth-power reduction in the required R_A for safe detection. All reflective fabrics in present technology have the property that the value of R_A at larger observation angles reduces at a lower rate than the distance effect. Therefore, it is not necessary to specify and measure R_A at closer distance or larger observation angles than what required at the critical observation angle.

Appendix B

Required Minimum Visual Reflective Area

The required reflective area must be designed to meet the requirement that the minimum luminous intensity R_I (= $A_I \times R_A$) > 0.3 cd.lx^{-1} , the required visual planer area $A_I = R_I / R_A$. Average R_A is equal to $\sum R_A \times 0.3$, considering the R_A of the 10% area with entrance angle not measurable equal to zero.

For area performance material

Given Observation Angle at 12', $\sum R_A = 37$ cd/lx/m^2

Average $R_A = \sum R_A \times 0.3$

$R_I = R_A \times A_I = 0.3$ cd/lx

$A_I = 0.3$ cd/lx $\div$ $R_A = 0.3$ cd/lx $\div$ (37 cd/lx/m^2 $\times$ 0.3) = 270 cm^2

Given Observation Angle at 22', $\sum R_A = 30$ cd/lx/m^2

$R_I = R_A \times A_I = 0.3$ cd/lx

$A_I = 0.3$ cd/lx $\div$ $R_A = 0.0333$ m^2 = 333 cm^2

Given Observation Angle at 22', $\sum R_A = 17$ cd/lx/m^2

$A_I = 0.3$ cd/lx $\div$ $R_A = 0.0588$ m^2 = 588 cm^2

For solid performance material

Given Observation Angle at 12', $\sum R_A = 277$ cd/lx/m^2

Average $R_A = \sum R_A \times 0.3$

$A_I = 0.3$ cd/lx $\div$ $R_A = 0.0036$ m^2 = 36 cm^2

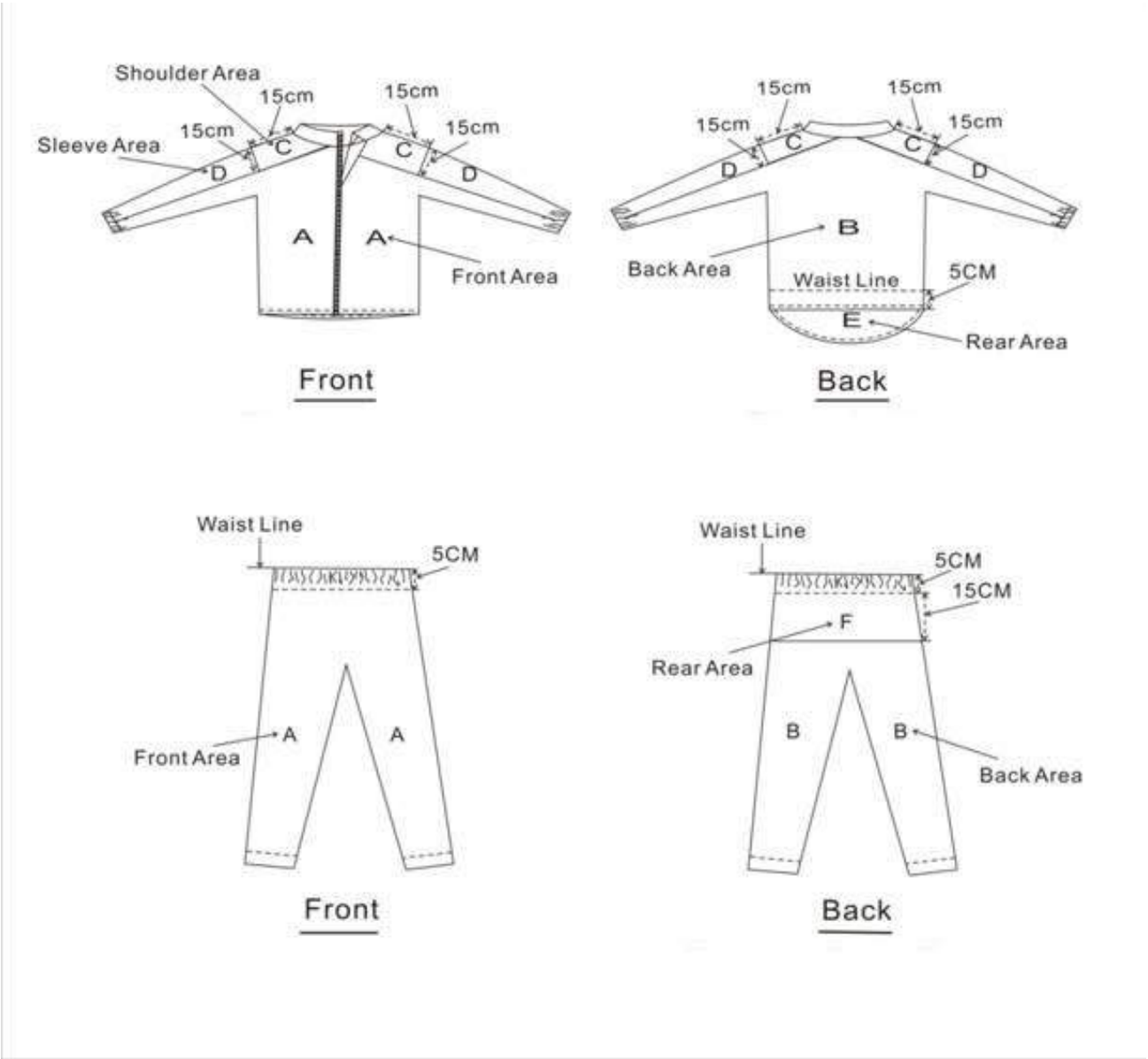
Given Observation Angle at 22', $\sum R_A = 223$ cd/lx/m^2

$A_I = 0.0045$ m^2 = 45 cm^2

Given Observation Angle at 34', $\sum R_A = 57$ cd/lx/m^2

$A_I = 0.0175$ m^2 = 175 cm^2

Figure B-1. Graphic Terminologies of the Reflective Areas in each Observation Directions



Appendix C

Visual Area Computation

While performance Level is determined based on location/situation of the risk environment where the protection afforded by clothing to this standard is required, performance Class will involve consideration of the activity which may affect an observer's ability to detect that the user is present. To ensure the clothing is designed effectively for the purpose, visibility in each of direction is analyzed based on Section 5.4; and samples are obtained and measured in according to IHVCA Test Method 001-2011; measurement data of each area are collected and analyzed as in Table D-1 to determine the visual A_I in each direction.

Table C-1 Converting Factor of Measured Area A_M to Planar Area A_P

Reflective Part	Measured Area (A_M)	Observation Direction				
		Font	**Back**	**Side**	**Top**	**Rear**
Front	A1	A1 X 64%	0	A1 X 8%	A1 X 5%	0
Back	A2	0	A2 X 64%	A2 X 8%	A2 X 5%	A2X 5%
Shoulder	A3	A3 X 32%	A3 X 32%	A3 X 20%	A3 X 64%	0
Sleeve	A4	A4X 32%	A4 X 32%	A4 X 32%	A4 X 26%	0
Rear	A5	0	A5 X 64%	A5 X 16%	A5 X 5%	A5 X 64%
	Total. A= ∑(A1..A5)	**A_P=∑(..)**	**A_P=∑(..)**	**A_P=∑(..)**	**A_P=∑(..)**	**A_P=∑(..)**

Appendix D

Performance Class Determination

Reflective safety clothing shall be designed detectable by vehicle drivers in front of headlight after dark in critical detection distance to avoid accidents. The required Luminous Intensity (R_I) shall be no less than 0.3 $cd.lx^{-1}$ in critical detection distance of 140 meters.[5] Manufacturer may choose solid performance, area performance retro reflective material or both with coefficient of retroflection index R_A meets or above the requirement of Table 1 or Table 2 and certified by ISO 17025 accredited laboratory and the A_I as computed in Table C-1 shall be equal or larger than the required minimum A_I as defined in Section 5.4.4, Table 3. The visual area A_I shall equal or exceed the required A_I to be visible by the vehicle operator. The required visibility for each performance Class is tabulated in Table D-1.

Table D-1 Performance Class According to the Planar A_P > Required Planar Area A_I

❖ Separated Performance ❖ Combined Performance	Level:_____ Required Minimum A_I:_____ (As defined in IHVCA Section 5.3.4 Table 1) Class:_____					
	Font	Back	Side	Top	Rear	Pass/ Failed
Class 1	$A_P > A_I$	$A_P > A_I$	-	-	-	
Class 2	$A_P > A_I$	$A_P > A_I$	-	$A_P > A_I$	-	
Class 3	$A_P > A_I$	$A_P > A_I$	$A_P > A_I$	$A_P > A_I$	-	
Class 4	$A_P > A_I$	$A_P > A_I$	$A_P > A_I$	$A_P > A_I$	$A_P > A_I$	

Notes: 1.The converted Planar Area A_P must be equal to or larger than the required minimum A_I.

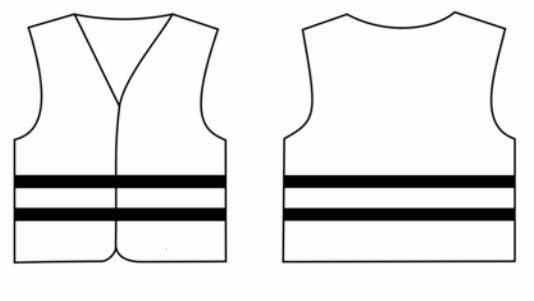
2. For garments containing both of Solid Performance and Area Performance materials the required visual area A_I of the Solid Performance material may revert to equivalent Area Performance visual area by the ratio of visual area in Table 3.

Appendix E

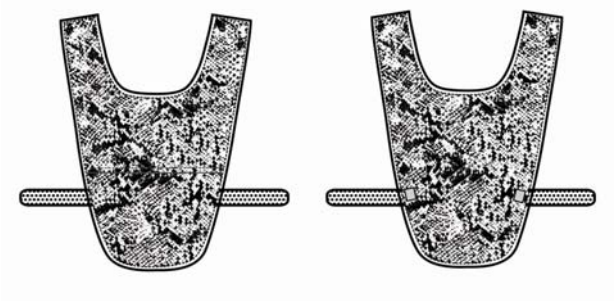
Examples of Garment Design

(Appendix E is not part of IHVCA Reflective Safety Clothing Standard but is included for information only)

Figure E-1. Performance Class 1:

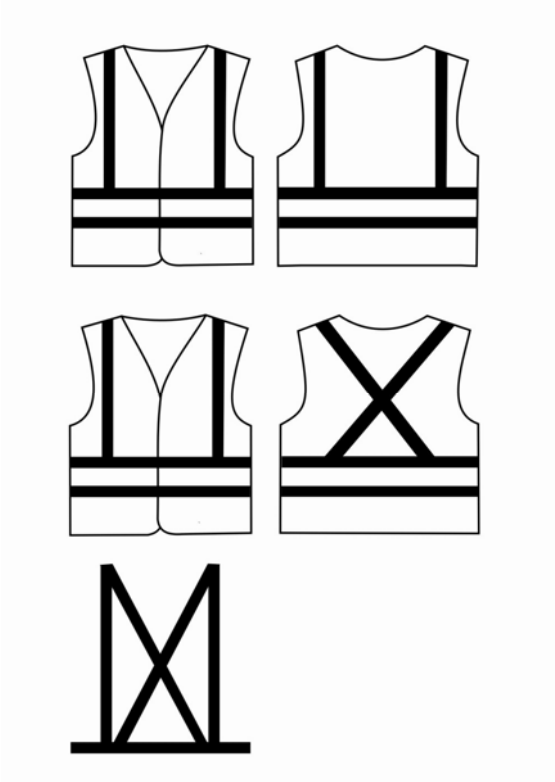


Solid Performance

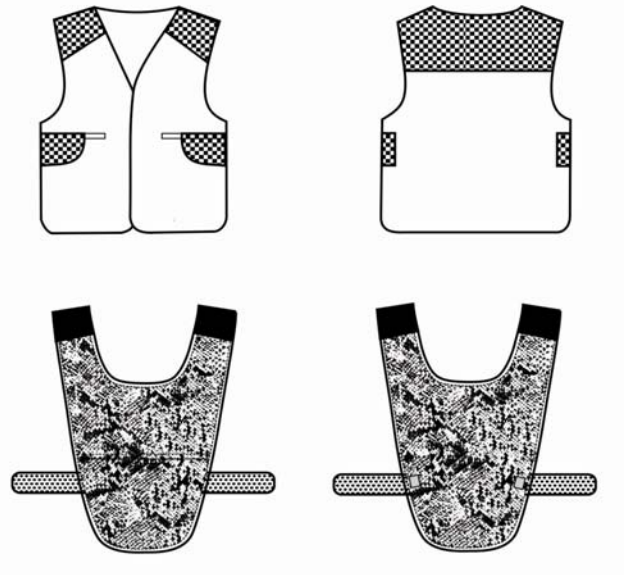


Area Performance

Figure E-2. Performance Class 2

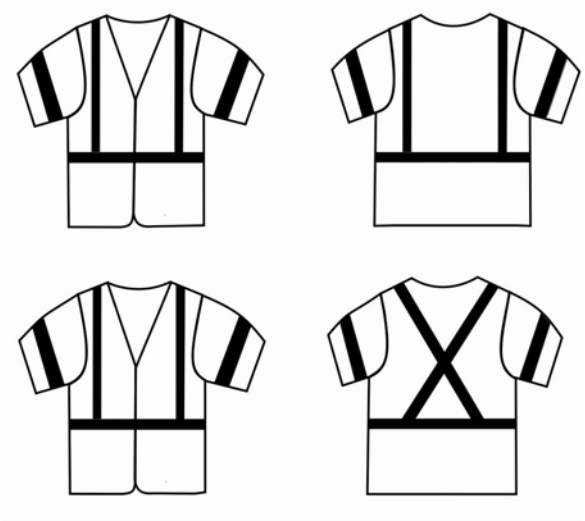


Solid Performance

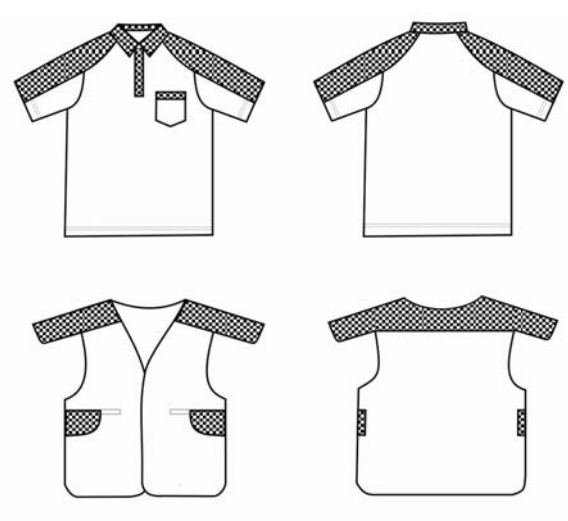


Area Performance

Figure E-3. Performance Class 3

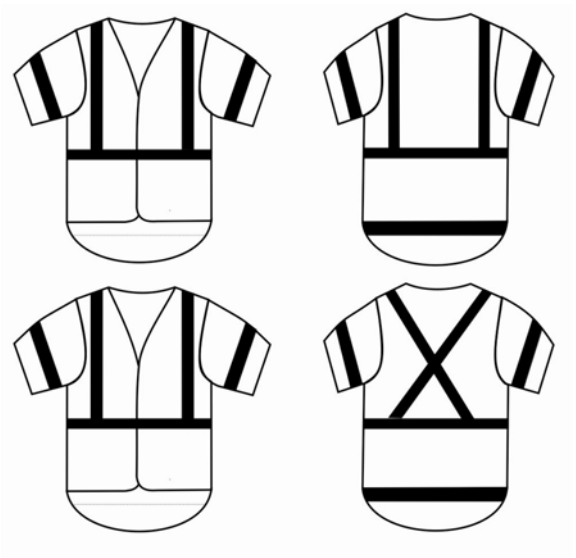


Solid Performance

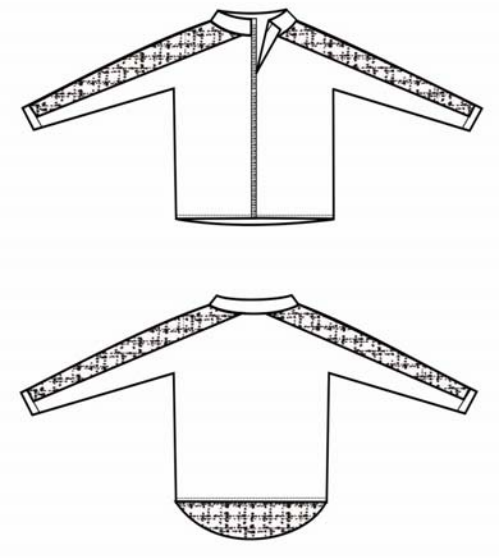


Area Performance

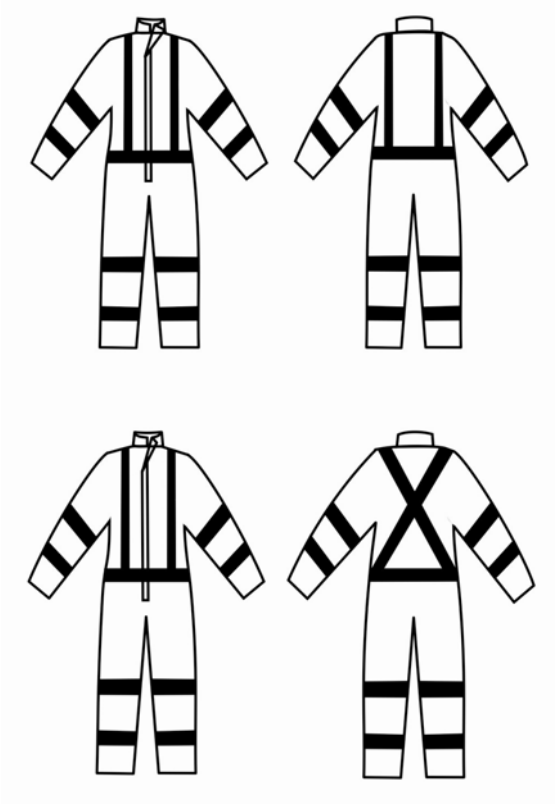
Figure E-4. Performance Class 4



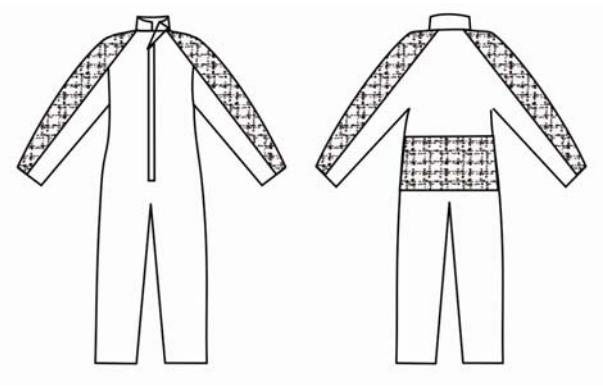
Solid Performance



Area Performance

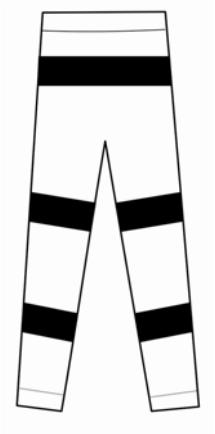


Solid Performance

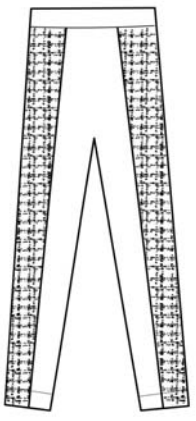


Area Performance

Figure E-5. Trousers or Pants



Solid Performance



Area Performance

Appendix F

Certificate

The below certificate is to be used for certification of the reflective safety clothing by manufacturers. Retroreflective materials and background materials shall be certified by 3rd party ISO/IEC 17025:2005 accredited laboratory.

IHVCA Reflective Safety Clothing Compliance Certificate

It is hereby certified that the subject sample meets all of the requirements as stated in IHVCA Standard of Reflective Safety Clothing as a compliant Reflective Safety Clothing of Performance Level and Class certified herein. All relevant materials have been 3rd party certified with documents referenced under this certificate number. The subject item has been measured for the appropriate amount of visible reflective material and background material for the smallest size offered for this product.

Model Number _____ Brand Name _____

Manufacturer _____

Visibility Performance Level _____

Visibility Performance Class _____

Area of Background Material _____

Certified by:

Company Name_____

Address_____

City, State, Zip_____

Country_____

Signed:_____Sealed:_____

Name:_____Date:_____

The undersigned hereby warrants that he/she is authorized to legally bind the organization identified above.

Bibliography

The following referenced documents are indispensable for developing, maintaining, and applying IHVCA Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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Sayer, James R., and Mary Lynn Mefford, *High – Visibility Safety Apparel and the Night Time Conspicuity of Pedestrians in Work Zones,* The University of Michigan Transportation Research Institute, UMTRI Report No. 2003-29, Ann Arbor, MI, 2003, pp.22.

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[Could be Appendix G: List of Organizations with established standards that being mentioned or applied to the IHVCA Reflective Clothing Standards. Keep (add back) ANSI.]

ASTM

American Society for Testing and Materials (ASTM) develops and delivers voluntary consensus standards to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence. ASTM's standards development is driven by the contributions of its members: more than 30,000 of the world's top technical experts and business professionals representing 135 countries. ASTM members deliver the test methods, specifications, guides, and practices that support industries and governments worldwide. Contact: ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 USA

1. ASTM D1424 Standard Test Method for Tearing Strength of Fabrics by Falling-Pendulum Type (Elmendorf) Apparatus, 1996

2. ASTM D3787 Standard Test Method for Bursting Strength of Knitted Goods - Constant-Rate-of- Traverse (CRT) Ball Burst Test, 2001

3. ASTM D5034 Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test), 1995

4. ASTM D5489 Standard Guide for Care Symbols for Care Instructions on Textile Products, 2001 a

5. ASTM D1776 Standard Practice for Conditioning Textiles for Testing, 1990

6. ASTM E96 Textiles - Standard Test Methods for Water Vapor Transmission of Materials, 2000

7. ASTM E284 Standard Terminology of Appearance, 1996

8. ASTM E808 Standard Practice for Describing Retroreflection, 2001

9. ASTM E809, Standard Practice for Measuring Photometric Characteristics of Retroreflectors, 2008

10. ASTM E1164 Colorimetry - Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation, 1994 2002

11. ASTM E1501 Standard Specification for Nighttime Photometric Performance of Retroreflective Pedestrian Markings for Visibility Enhancement, 1999

12. ASTM F923 Standard Guide to Properties of High Visibility Materials Used to Improve Individual Safety, 2002The following European Norm (EN) and International Organization of Standards (ISO) references are available from the American National Standards Institute

AATCC

The American Association of Textile Chemists and Colorists (AATCC) is a nonprofit organization that serves textile professionals since 1921. AATCC has individual and corporate members in more than 60 countries. The Association is internationally recognized for its standard methods of testing dyed and chemically treated fibers and fabrics to measure and evaluate such performance characteristics as colorfastness to light and washing, smoothness appearance, soil release, shrinkage, water resistance, and the many other conditions to which textiles may be subjected. AATCC is headquartered in Research Triangle Park, NC, USA.

1. AATCC - EP1 Textiles - Test Procedure for color change - Gray Scale for Color Change

2. AATCC - EP2 Textiles - Test Procedure for staining - Gray Scale for Staining

3. AATCC 8, Textiles - Tests for colorfastness - Colorfastness to Crocking, 2001

4. AATCC 15, Textiles -Tests for colorfastness - Colorfastness to Perspiration, 2002

5. AATCC 16 Textiles - Colorfastness to Light (Test Option 3) - Xenon Arc Lamp, Continuous Light, 1998

6. AATCC 22 Textiles - Tests for water resistance - Water Repellency: Spray Test, 2001

7. AATCC 35 Textiles - Tests for water resistance - Water Resistance: Rain Test, 2000

8. AATCC 61 Textiles - Tests for color fastness - Colorfastness to Laundering, Home and Commercial: Accelerated, 2001

9. AATCC 96 Textiles - Tests for dimensional changes - Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics Except Wool, 1999

10. AATCC 107 Textiles - Tests for colorfastness - Colorfastness to Water, 2002

11. AATCC 127-1998, Textiles - Tests for water resistance - Water Resistance: Hydrostatic Pressure Test , 1998

12. AATCC 132 Textiles - Tests for colorfastness - Colorfastness to Dry-cleaning, 1998

13. AATCC 133 Textiles - Tests for colorfastness - Colorfastness to Heat: Hot Pressing, 1999

14. AATCC 135 Textiles - Test for dimensional changes - Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics, 2000

15. AATCC 158, Textiles - Test for dimensional changes - Dimensional Changes on Dry-cleaning in Perchlorethylene: Machine Method, 1995

CIE

The International Commission on Illumination (usually known as the CIE for its French-language name Commission Internationale de l'Eclairage) is the international authority on light, illumination, color, and color spaces. CIE provided recommendations about the precise way in

which the basic principles of light and color measurement should be applied. The CIE has its headquarters in Vienna, Austria.

1. CIE 15:2004, Colorimetry

2. CIE 17.4:1987, International lighting vocabulary

3. CIE 54.2:2001, Retroreflection - Definition and measurement

EN or CEN

The European Committee for Standardization or Comité Européen de Normalisation (CEN), is a non-profit organization whose mission is to develop, maintain, and distribute coherent sets of European Standards (ENs) since 1961. Some of these standards are voluntary, whereas other standards such as harmonized standards have been made effectively mandatory under EU law. CEN is officially recognized as a European standards body by the European Union. The current CEN Members are Iceland, Norway, Switzerland and all EU member states: Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

1. EN 340, Protective clothing - General requirements

2. EN 530:1994, Method 2 Abrasion resistance of protective clothing material

3. EN 343:2003+A1, Protective clothing - Protection against rain

4. EN 530:1994, Abrasion resistance of protective clothing material - Test methods

5. EN 1150:1999-02, Visibility clothing for non-professional use- Test methods and requirements

ISO

The International Organization for Standardization known as ISO, is an international-standard-setting body composed of representatives from various national standards organizations. Founded on February 23, 1947, the organization promulgates worldwide proprietary industrial and commercial standards. ISO defines itself as a non-governmental organization. In practice, ISO acts as a consortium with strong links to establish government rules and regulations. ISO has its headquarters in Geneva, Switzerland.

1. ISO 105-A02, Textiles - Tests for color fastness - Part A02: Grey Scale for assessing change in color

2. ISO 105-A03, Textiles - Tests for color fastness - Part A03: Grey Scale for assessing staining

3. ISO 105-B02:1994, Textiles - Tests for color fastness - Part B02: Color fastness to artificial light: Xenon Arc fading lamp test

4. ISO 105-C06, Textiles - Tests for color fastness — Part C06: Color fastness to domestic and commercial laundering

5. ISO 105-D01, Textiles - Tests for color fastness — Part D01: Color fastness to dry cleaning

6. ISO 105-E04, Textiles - Tests for color fastness — Part E04: Color fastness to perspiration

7. ISO 3175-2:1998 Textiles - Determination of dimensional change on dry cleaning in perchlorethylene - Machine method

8. ISO 4675:1990 Rubber or plastic coated fabric - Low-temperature bend test

9. ISO 5081 Textiles - Woven Fabrics - Determination of breaking strength and elongation (Strip method)

10. ISO 6330:2000 Textiles - Domestic washing and drying procedures for textile testing

11. ISO 7854:1997 Rubber- or plastics-coated fabrics - Determination of resistance to damage by flexing (dynamic method)

NFPA

The National Fire Protection Association (NFPA) is a U.S. organization, albeit with some international members, charged with creating and maintaining minimum standards and requirements for fire prevention and suppression activities, training, and equipment, as well as 300 safety codes and standards since 1896. This includes personal protective equipment utilized by firefighters while extinguishing a blaze. Contact: NFPA, 1 Batterymarch Park, Quincy, Massachusetts, USA 02169-7471 Tel: (617) 770-3000.

1. NFPA 1971 *Standard on Protective Ensemble for Structural and Proximity Fire Fighting*

2. NFPA 1977 *Standard on Protective Clothing and Equipment for Wildland Fire Fighting*

3. NFPA 2112 *Standard on Flame-Resistant Garments for Protection of Industrial Personnel against Flash Fire*

4. NFPA701 2004, *Standard Method of Fire Tests for Flame Propagation of Textile and Films*

5. NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operation*