High-visibility retro-reflective materials

In this article, SATRA looks at one of the essential components of high-visibility clothing – retro-reflective materials.

High-visibility materials are used to make an object, animal or person visually stand out from the surrounding environment. SATRA's laboratories test different types of high-visibility products and materials, particularly those that are used in personal protective equipment (PPE).

As a European Notified Body, SATRA is also responsible for certifying different types of high-visibility PPE, including firefighting equipment. The current European standard for high-risk situation high-visibility PPE specifies the application of retro-reflective materials in the form of tapes that are placed on a garment according to specific design criteria. The main requirement is that these tapes encircle the torso and limbs – the primary components of the human body. The application of tapes to a garment in this manner is intended to make a body visible when it is viewed in different orientations and postures.

Under daylight conditions, colored fluorescent high-visibility materials are used to produce a contrast of appearance against a particular environment – fluorescent yellow, orange-red or red materials being those most commonly used. Low-light or nighttime high-visibility materials are those that can be said to have retro-reflective properties. A large proportion of light that is shone onto these materials is reflected back towards the origin of the light source. The current European standard for high-risk situation high-visibility PPE specifies the application of retro-reflective materials in the form of tapes that are placed on a garment according to specific design criteria. The main requirement is that these tapes encircle the torso and limbs – the primary components of the human body. The application of tapes to a garment in this manner is intended to make a body visible when it is viewed in different orientations and postures. For other types of high-visibility PPE which are intended for use under non-high-risk circumstances, a standard currently under development will permit retro-reflective materials to be applied in a freer manner – for example, patches and logos can be used. This standard will define high-visibility PPE clothing and accessories for use under medium-risk conditions.

The standards for high-visibility garments, and those for accessories, set out the minimum performance requirements for retro-reflectivity. These include retro-reflectivity testing after potentially destructive pre-treatments have been applied. To maintain an effective level of retro-reflectivity, materials must retain their performance after any treatment which is prescribed for them. For example, if a retro-reflective tape is claimed to be effective after ten dry cleaning cycles, then evidence that the minimum specified level of retro-reflectivity can be maintained after cleaning must be established by testing.

The retro-reflectivity of tape may be achieved by different means. The most commonly used type is one that uses bead...
Microscopic glass beads of different diameters are distributed over the surface of a substrate layer, which is usually, but not exclusively, a textile material. These beads are stuck to the substrate by a silvered adhesive layer which forms a mirror around that part of the bead that is embedded. The performance of the tape is determined by several factors, including bead sizes, how spherical they are, their distribution over the surface of a substrate layer and the depth to which they are embedded in the adhesive layer. The durability of a tape depends not only upon how well individual beads are held in position on the tape, but also the flexibility of the adhesive layer and the inherent strength of the substrate material. Any loss of beads will, of course, lead to a reduction in the retro-reflective performance of the tape.

Another type of retro-reflective tape often used on high-visibility PPE incorporates micro-prismatic structures. This type of material is embossed with many reflectors that are shaped like the corners of a cube (figure 2). These may be arranged in different orientations to provide different paths of retro-reflection. Each micro-prismatic shape functions by reflecting light from the three sides of its structure. The geometry of these micro-prisms is such that light is reflected back towards its source. The collective effect of the many micro-prisms embossed on a tape provides the required level of retro-reflection.

A retro-reflector does not return light shone onto it exactly to the point of origin. Rather, it returns a cone of retro-reflective light towards the source of illumination. Retro-reflective light can therefore only be seen if a viewer is within the cone of retro-reflection. For example, a car driver can see a pedestrian wearing a retro-reflective garment because the driver sits more or less behind the headlights of the vehicle. The laboratory measurement of retro-reflective materials is undertaken to define the effective cone of retro-reflection of a material (figure 3).

At present, the following standards are applied to PPE high-visibility products sold within Europe:

- EN ISO 20471:2013 + A1:2016 – High visibility warning clothing for professional use
- EN1150:1999 – Visibility clothing for non-professional use

The standard for professional use high-visibility garments permits the manufacture of three classifications of garment. Each classification is based on minimum allowances for both fluorescent material and tape that can be used in making a garment. The retro-reflective performance requirements for ‘separate performance’ tape (material intended to exhibit retro-reflective properties) and ‘combined performance’ tape (material intended to exhibit both background fluorescence and retro-reflective properties) are shown in table 1.

Therefore, manufacturers should always make sure that the retro-reflective material they intend to use meets their market’s demands.

Buyers of high-visibility garments may also specify that retro-reflective tapes are able to withstand specific cleaning treatments, usually appropriate to the type of contamination that their clothing may experience. For example, clothing that becomes contaminated with oil may require dry cleaning. It is, therefore, important to determine whether a retro-reflective material has the ability to withstand repeated solvent immersion.

SATRA can carry out independent checks on retro-reflective materials to ensure that they meet the minimum performance levels that are demanded by standards. Additionally, testing can be arranged to determine whether materials have the durability requirements that may be demanded by individual manufacturers or users of high visibility garments.

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</table>

Table 1: Minimum coefficients of retro-reflection in cd/(lx·m²) for combined performance material

How can SATRA help?

Please email ppe@satra.com if you require help with SATRA high-visibility tape testing or certification.