TECHNICAL REPORT

ISO/TR 23383

First edition
2020-11

Textiles and textile products — Smart (Intelligent) textiles— Definitions, categorisation, applications and standardization needs

Textiles et produits textiles — Textiles intelligents — Définitions, catégorisation, applications et besoins de normalisation

Reference number
ISO/TR 23383:2020(E)

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Published in Switzerland

Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 38, *Textiles*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 248, *Textiles and textile products,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Terms like “smart textile” and “intelligent textile” mean different things to different people. However, there is a common agreement that these are textiles or textile products that possess additional intrinsic and functional properties not normally associated with traditional textiles.

Although adjectives such as “smart” or “intelligent” are mainly intended for marketing purposes, more technically correct definitions will not prevent the use of this terminology by textile manufacturers or by the general public. Nor will the unintended inclusion of “non-smart” products make products any less safe or fit for purpose.

The standardization of smart textiles or smart textile products or systems is not straightforward because it involves an overlap between the standardization of the “traditional” textile product, e.g. a fire fighter's jacket, and the standardization of the additional intrinsic functional properties of the “smart product”. This overlap can manifest itself in a number of areas, possibly including:

— Expertise: the knowledge and experience of standardization for the textile properties and for the additional properties (temperature sensing, variable thermal insulation properties) can come from different unrelated standardization groups. To take the above example, there should be input from standardization groups working in the areas of textiles, medical devices and electric or electronic devices.

— Testing: there is a need to test the additional functional properties to specific textile test standards and vice versa. Again, with the same example, the electronic elements should be assessed for their resistance to cleaning and the textile elements need to be tested for electrical safety.

— Unexpected and/or unintended synergies: these might result from the combination of technologies in smart textiles and need be recognized and addressed by standardization, wherever possible. For example, the presence of conductive fibres to incorporate a personal stereo into a smart raincoat might increase the risk of the wearer suffering a lightning-strike in a thunderstorm. This is despite the fact that neither rainwear nor personal stereos, when separate, need to be assessed against this risk.

— Legislation: Certain textile product groups, e.g. protective clothing, geotextiles or textile floor coverings, are in addition subject to specific national and/ or regional legislation. It can be necessary to simultaneously address the requirements of legislation covering more than one product category. For example, a “classic” fire fighter's suit needs comply with the requirements for personal protective equipment, whereas a “smart” fire fighter's suit with built-in electronic and ICT features should also comply with the applicable provisions for electronic equipment and ICT. Conformity assessment will therefore need to follow the conformity assessment schemes for all applicable legal provisions.

The purpose of this document is to identify the considerations that need to be addressed when writing standards for smart textiles or applying existing standards to them. This information can be of use to:

— end-users, in determining whether a product has indeed been fully assessed;

— conformity assessment bodies, as a guide towards assessing products according to the appropriate standards;

— specification writers, as a guide to writing new specific standards for smart textiles;

— manufacturers of smart textiles, to advise them on appropriate product testing and on suitable ways to substantiate product claims;

— market surveillance authorities, to help in the assessment of product claims, product safety and fitness for purpose.

The factual information in this document is available elsewhere in a more comprehensive form and each individual item will inevitably be common knowledge to at least one group of readers. The aim of this document is to guide readers through those areas, with which they are not familiar, and to direct them

towards further, more specialized reading. In accordance with ISO rules, this document is intended to be reviewed regularly to keep it in line with technical and market evolutions.

Textiles and textile products — Smart (Intelligent) textiles— Definitions, categorisation, applications and standardization needs

1 Scope

This document provides definitions in the field of "smart" textiles and textile products as well as a categorization of different types of smart textiles. It describes briefly the current stage of development of these products and their application potential and gives indications on preferential standardization needs.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
textile fibre
unit of matter characterised by its flexibility, fineness and high ratio of length to maximum transverse dimension, which render it suitable for textile applications

[SOURCE: Regulation EU 1007/2011, Article 3, 1. (b), (i)]

3.2
textile product
product made of *textile fibres* (3.1), yarns and/ or fabrics and intended to be used, as such or in conjunction with other textile or non-textile elements

3.3
functional textile product
textile product to which a specific function is added by means of material, composition, construction and/or finishing (applying additives, etc.)

3.4
smart textile product
intelligent textile product
interactive textile product
functional textile product (3.3) which interacts reversibly with its environment, or responds or adapts to changes in the environment

Note 1 to entry: The term "smart textile" can refer to either a "smart textile product" or a "smart textile system". Only the context, in which the term is used, determines which one of the two is intended.

3.5
environment
surroundings
circumstances, objects, or conditions, which surround a textile material or textile product or the user of that material or product

3.6
non-textile element
product which is not composed of *textile fibres* (3.1)

Note 1 to entry: Non-textile element(s) can include elements used for garment construction, for example slide fastener(s), press stud(s), button(s), membranes, non-textile patches, prints, coatings, finishes.

Note 2 to entry: Non-textile element(s) can also include elements with functionalities listed in 4.1 and 4.2.

3.7
textile system
assemblage of textile product(s) and non-textile element(s)

3.8
smart textile system
textile-based system which exhibits an intended and exploitable response as a reaction either to changes in its surroundings/environment or to an external signal/input

4 Functional and smart textile products

4.1 Functional textile products

4.1.1 General

Functional textile products can be components of smart textile systems and hence functional textile products, which are relevant for these smart textile systems, are discussed here. This is illustrated by the following examples.

EXAMPLE 1 A textile resistance heater

— Functional textile product: a conductive material forming the basis of a resistance heater in a textile system.

— Smart textile system: a textile resistance heater as (part of) a textile system, connected to an electrical power supply which can only be switched on and off manually or a resistance heater as part of a textile system, connected to an electrical power supply with a regulated power output and equipped with a temperature sensor as to maintain a constant temperature around the heater.

EXAMPLE 2 Optical fibres

— Functional textile product: optical fibres used as part of a textile system

— Smart textile system: optical fibres as (part of) a textile system, connected to a light source which can only be switched on and off manually or optical fibres as part of a textile system, connected to a light source with a regulated power output and equipped with a sensor to adjust the illumination level to the amount of light present due to other light sources in the surroundings of the textile system.

4.1.2 Electrically conductive textile products

Electrically conductive textile product conducts an electrical current or supply an electric field to a device. Electrical conduction is the movement of electrically charged particles through an electrical

conductor, called an electric current. The charge transport can result as a response to an electric field or as a result of a concentration gradient in carrier density, i.e. by diffusion.

NOTE A material is considered to have a "good electrical conductivity" if it has a specific conductivity (resistivity) of > 10^2 S/m (<10^4 Ω·cm). A material is considered to have "ohmic behaviour" if its resistance follows Ohms law, a fundamental law of electricity, stating that the voltage at the terminals of an ideal resistor is proportional to the current in the resistor[1)]. The materials with the highest specific conductivity are metals. Some polymers and ceramics can also show ohmic behaviour, e.g. intrinsically conductive polymers (e.g. doped polyaniline) or indium tin oxide (ITO).

4.1.3 Thermally conductive textile products

Thermally conductive textile products conduct heat. The transfer of thermal energy in a substance is due to a temperature gradient, i.e. from a region of higher temperature to a region of lower temperature, acting to equalize temperature differences.

Metals have thermal conductivities above approximately 20 W/(m·K) and are considered to be very good thermal conductors. Their thermal conductivity increases with their electrical conductivity. There are also non-metallic elements and compounds that are (very) good thermal conductors (e.g. carbon and boron nitride).

Applications in smart textile systems can be as a heat sink, e.g. for cooling electronic components.

4.1.4 Thermally radiative (emissive) textile products

Thermally radiative (emissive) textile products radiate heat, i.e. they emit electromagnetic radiation in the infrared range of 750 nm to 100 µm from their surface due to their temperature.

Thermal radiation (emission) can be utilized in the form of a resistance heater, where the resistance of a conductor is used to heat the conductor to a sufficiently high temperature to generate heat radiation or as a heat exchanger, e.g. a pipe with hot air or hot water flowing through it.

Applications in smart textile products are as thermal heaters, as described in 4.1.1.

4.1.5 Optically conductive textile products

Optically conductive textile products transport (visible) light, i.e. electromagnetic radiation in the range of 400 nm to 750 nm.

Optical fibres from glass or plastic keep the light in their core by total internal reflection, i.e. the fibre acts as a waveguide. Optical fibres are widely used in fibre-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communications. Fibres are used instead of metal wires because signals travel along them with less loss, and they are also immune to electromagnetic interference.

Fibres are also used for illumination, and are wrapped in bundles so they can be used to carry images, thus allowing viewing in tight spaces. Specially designed fibres are used for a variety of other applications, including sensors and fibre lasers.

4.1.6 Fluorescent textile products

Fluorescence is the molecular absorption of a photon, followed almost instantaneously by the emission of a less energetic photon. As the emitted photon is of lower energy than the absorbed photon, the emitted light will be of longer wavelength than the absorbed light, which allows, for example, to turn UV radiation into visible light.

1) www.electropedia.org IEV ref 131–15–08.

Fluorescence is used in high visibility clothing for safety purposes. Fluorescent textile products are available in a variety of colours from red to blue-violet. A variety of organic and inorganic materials show fluorescence.

4.1.7 Phosphorescent textile products

Phosphorescence is the molecular absorption of a photon, resulting in the formation of an excited state, followed by the emission of a less energetic photon. Since the emitted photon is of lower energy than the absorbed photon, the emitted light will be of longer wavelength. The lifetime of the excited state in phosphorescent materials can be very long, in the order of hours. This means that once activated, phosphorescent materials will continue to emit light for hours without any external power supply. This makes them suitable for emergency lighting in the case of power interruptions or for watches, toys, apparel, giving a "glow in the dark" effect.

Examples of phosphorescent materials are doped (mixed) sulphides (ZnS, (Cd, Zn)S, (Ca, Sr)S) or doped (mixed) oxides ($SrAl_2O_4$) but can also be organic molecules.

4.1.8 Textile products releasing substances

These textile products release substances at a molecular level under the influence of an external stimulus. The substances used for this purpose are pharmaceuticals, cosmetics, fragrances, etc. They are bonded to the textile structure by micro-encapsulation or by surface bonding.

NOTE Some of these textiles are referred to as cosmetotextiles (see CEN/TR 15917[1]).

The micro-encapsulation technique makes use of small capsules, in which the substance to be released is enclosed. When the shell of these capsules is pierced due to an external stimulus, the substance is released. The different stimuli that can cause piercing of the shell include mechanical force, heat, pH and contact with water.

The surface bonding technique makes use of substances (loosely) bonded to the surface of the textile material and released during the use of this material. The nature of the bonding and the surroundings of the material determines the release rate.

4.2 Smart (intelligent) textile products

4.2.1 General

In this subclause, examples (non-exhaustive) for different smart (intelligent) textile products are described. The described textile products (see 4.2.2 to 4.2.14) can be used on their own or in combination with other (non)smart textile products or used in textile systems. The latter are described in Clause 5.

NOTE Some of the smart functionalities can also be achieved by non-textile elements. Therefore, we will be referring to textile products to clearly make the distinction.

Table 1 provides an overview of the most common stimulus-response pairs and the corresponding effect materials or structures can exhibit.

