TECHNICAL REPORT

ISO TR 9240

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Textiles — Design of apparel for reduced fire hazard

Textiles — Conception des vêtements pour la réduction des risques de feu

Reference number
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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9240, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 38, *Textiles*, Sub-Committee SC 19, *Burning behaviour of textiles and textile products*.

A bibliography is provided in annex A.

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Introduction

Garment style or design is an important contributing factor in the fire behaviour of apparel. As early as the 1890s, the hazards of long flowing dancers' dresses and naked-flame lights on theatre stages were reported in the United Kingdom.

As stated in referenced publications (see Bibliography, items 1. and 2.), the fire behaviour of garments is primarily affected by:

a) the fibre content;

b) the construction and mass per unit area of the material(s);

c) the surface characteristics of the material; and

d) the design of the garment.

However, it should be noted that the reaction of persons whose clothing is alight can have a significant effect on the burning behaviour of their garments.

Results of investigations into the burning behaviour of garments on manikins have been reported (see Bibliography, items 2., 3., 4. and 5.). In all cases the results show that under controlled conditions on a stationary subject, free flowing garments represented a greater hazard than less free flowing garments. The limited information from

case histories also indicates that accidents involving loosely fitting garments result in more serious burn injuries than those involving more tightly fitting garments. Of 641 accidents recorded, in which garments were directly ignited without flammable liquids or gases, 64% were of the dress/shift or loose top category. In addition, the burns resulting from accidents involving dress/shifts were more serious than those garments with "fire stops" such as belts (see Bibliography, item 6.).

Ignition occurred in most cases at the loosest area of the garments. Garments worn during burn accidents were classified according to fit at the point of ignition:

Loose 42%

Medium 24%

Tight 2%

Unknown 32% (see Bibliography, item 6.)

Buchbinder (see Bibliography, item 7.) also describes which case studies highlight the involvement of loosely fitting garments in fire accidents.

Additional information based on manikin trials shows that garment design is a sufficiently important factor in fire behaviour to be used as the basis for the designation of some garments as having a lower risk. This designation is used in addition to the usual one of low fire risk based on the burning behaviour of fabrics.

Krasny and Fisher (see Bibliography, item 8.) stress the importance of garment geometry. In trials using a manikin, the effect of "chimneys" in garments was noted which caused an increase in the area of the manikin which was raised to a high temperature. Fire stops such as belts decreased the area which was raised to a high temperature.

In 1976, a U.S. Standard was proposed (see Bibliography, items 9. and 10.), based on the premise that the probability of ignition of apparel depends on the ignition time of fabrics and the design of garment made from the fabric. The proposed standard divides garments into four categories according to looseness of fit. It stipulates different minimum levels of heat transfer rate and ignition time of the fabrics from which the garments are made according to the Mushroom Apparel Flammability Tester (MAFT). The garment classification of the proposed standard was based on the concept that long and/or loose garments are more hazardous than tight fitting garments which cover only half the body.

If the design of a garment is not considered in assessing the fire risk, some garments which are inherently "safe" will be condemned as unsatisfactory. Garments made according to the design limitations in this report do not require as severe restrictions on fabric burning behaviour as those required on garments designed to be more free flowing.

Principles

The following four principles form the basis of the recommendations of

the report:

a) Loose fitting garments sweep a greater area than close fitting garments, e.g., nightgowns versus pyjamas. Thus there is a greater opportunity for the fabric to come into contact with the source of ignition. Wearers of tighter fitting garments are less likely to be involved in fires, if the garment is the initial point of ignition. Similarly the risk of ignition is reduced by close fitting wrist cuffs and ankle cuffs.

b) The availability of air (oxygen) plays an important role in the flame spread rate of a burning fabric. In the case of a close fitting garment, less air is available on the inside of the garment in comparison with a loose fitting one. Consequently, a loose fitting garment will burn faster than a tight fitting one, increasing the burn potential to the wearer. In addition, there is evidence that a garment such as a nightdress may burn faster due to the "chimney" effect of the flame (see Bibliography, item 11.).

c) If the wearer is near a flame source, there is more chance of feeling the heat through the fabric before ignition takes place if it is close to the skin. Therefore, there is less risk to the wearer of a tighter fitting garment.

d) Restrictions in garments such as waist bands, may impede the spread of flame upwards and act as "fire stops." Total cessation of flame spread by such fire stops can result in a small localized burn rather than severe and extensive burns. (See Bibliography, item 4.)

Textiles — Design of apparel for reduced fire hazard

1 SCOPE

This report sets out the design characteristics to be considered in designing apparel with a reduced fire risk. It also indicates the need to consider the garment as a whole rather than just the flammability of the fabric, in order to economically minimize the risk of flame burns. The risk of burn injury due to garments made from inherently flammable fabrics can be substantially reduced using the criteria herein.

NOTES:

1. It is not possible to make garments such as nightgowns, dresses and skirts that will meet the requirements of this report.
2. Garments made from fabrics of low flammability (i.e., fabrics which are difficult to ignite and which are slow to spread flame) may be made to any design. The use of flammable trims and attachments may be permitted in limited amounts.

2 DEFINITIONS

The burning behaviour terms used in this Technical Report are defined in ISO 4880 (see Bibliography, item 12.).

3 CLASSIFICATION

Garments conforming to this Technical Report are made to a design which will inherently reduce the chance of ignition, and if ignited will reduce the rate of flame spread. The outside surface of the fabric in the garment should neither surface burn nor surface flash when tested using the method described in ISO 10047 (see Bibliography, item 13).

4 GARMENT DESIGN

4.1 Design Characteristics

Garments which meet the recommendations of this Report conform to the design criteria set out in 4.2 to 4.4. The maximum dimensions for garments are based on the body size that the garment is intended to fit. However, nightgowns, dresses and skirts cannot meet these design criteria.

NOTE: As these body sizes may vary from country to country, no attempt has been made to include them in the text.

4.2 Sleeves

In order to reduce fire hazards, garment sleeves are designed to have a width measurement at a point 3 cm below the armscye seam not greater than that given by formula (1) below, which is the maximum width of the sleeve below the point of measurement. The measurement so specified refers to the half-garment measurement taken at right angles to the longitudinal axis of the sleeve.

$$\text{Maximum arm width measurement, cm} = \frac{\text{upper arm girth} + 15}{2} \quad \ldots\ldots\ldots \quad (1)$$

4.3 Legs

4.3.1 Garment legs are designed to have a width measurement at a point 3 cm below the lowest part of the crotch seam not greater than that given by formula (2) below. At no point does the garment leg exceed this measurement. The width refers to the half-garment measurement taken at right angles to the longitudinal axis of the leg.

$$\text{Maximum leg width measurement, cm} = \frac{\text{thigh girth} + 15}{2} \quad \ldots\ldots\ldots \quad (2)$$

4.3.2 The garment leg width at the ankle is not greater than that at the knee.

4.4 Garment Jackets

4.4.1 Length -- The jacket is designed so that it does not extend beyond a point 3 cm below the crotch height.

4.4.2 Width -- The width at the lower hem of the jacket does not exceed the width given by the following formula (3) using allowances set out in Table 1.

$$\text{Maximum width, cm} = \frac{(\text{bust/chest girth} + \text{allowance})}{2} \quad \ldots\ldots\ldots \quad (3)$$

TABLE 1 -- GARMENT JACKET WIDTH ALLOWANCE

Bust/Chest Girth (cm)	Allowance (cm)
Up to 62	8
62 -- 74	10
74 -- 86	13
86 -- 100	18
100 -- 120	24

4.5 Fasteners

Garments fastened down the length of the top are designed to have a secure closure within 15 cm of the lower hem.