
**Protective clothing against heat and
flame —**

**Part 1:
Test method for complete garments —
Measurement of transferred energy
using an instrumented manikin**

Vêtements de protection contre la chaleur et les flammes —

*Partie 1: Méthode d'essai pour vêtements complets — Mesurage de
l'énergie transférée à l'aide d'un mannequin instrumenté*



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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 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html

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

This first edition of ISO 13506-1, together with ISO 13506-2, cancels and replaces the first edition of ISO 13506:2008, which has been technically revised. The assessment of skin burn injury has been transferred to ISO 13506-2.

A list of all parts in the ISO 13506 series can be found on the ISO website.

Introduction

The purpose of heat and flame-resistant protective clothing is to shield the wearer from hazards that can cause skin burn injury. The clothing can be made from one or more materials. The evaluation of materials for potential use in this type of clothing generally involves two steps. First, the materials are tested to gauge their ability to limit flame spread. They are then tested to determine the rate of transferred energy through them when exposed to a particular hazard. A variety of test methods are used in these two steps. The test method selected depends on the nature of the potential hazards and the intended end use of the materials. Once suitable materials have been identified, they can be made into complete garments or ensembles for testing on a manikin-fire exposure system.

Laboratory bench scale transferred energy tests are used to select suitable materials for a protective clothing ensemble. While these tests can allow ranking of garment or ensemble materials and components, the tests do not allow a complete assessment of a garment or ensemble made of the materials.

Bench scale transferred energy test methods use small amounts of material, up to 150 mm × 150 mm in area, and hold the material initially flat, either in a vertical or horizontal plane. Multiple layers are used where appropriate (e.g. fire-fighting ensembles). In this case, the layer normally worn on the exterior is exposed directly to the energy source, while the layer normally worn on the inside is away from the energy source. With the planar orientation and alignment of materials, shrinkage has little effect on the outcome of the test, unless the shrinkage is so severe as to cause holes to form in the material during the exposure to the energy source. Sagging, however, does directly affect the results, as an air gap can form or grow in size, adding an insulating effect. With the aforementioned test methods, it is possible to test seams, zippers, pockets, buttons or other closures, metal and plastic clips or other features that can be included in a complete garment such as heraldry, company logos, etc. However, it is often considered easier to evaluate these aspects together with the overall design features of a garment or ensemble that can affect the performance by testing complete garments or ensembles on a manikin. It is for this purpose that this document was established.

In the test method in this document, a stationary, upright adult-sized manikin is dressed in a complete garment and exposed to a laboratory simulation of a fire with controlled heat flux, duration and flame distribution. The average incident heat flux to the exterior of the garment is 84 kW/m², a value similar to those used in ISO 9151, ISO 6942 and ISO 17492. Heat flux sensors fitted to the surface of the manikin are used to measure the heat flux variation with time and location on the manikin and to determine the total energy absorbed over the data-gathering period. The data gathering period is selected to ensure that the total energy transferred has been completed. The information obtained can be used to assist in evaluating the performance of the garment or protective clothing ensembles under the test conditions. It can also be used to estimate the extent and nature of skin damage that a person would suffer if wearing the test garment under similar exposure conditions (see ISO 13506-2).

The manikin is used in a standing position in initially quiescent air. Controlled air motion for simulating wind effects or body movement is not presently possible. It is possible to move the manikin through a stationary flame but motion of this nature is not within the scope of this document. Variations in the fit of the test garment that can occur when sitting or bending are not evaluated.

The fire simulations are dynamic. As such, the exposure is more representative of an actual industrial accident fire than the exposures used in bench scale tests (see [Annex B](#)). The heat flux resulting from the exposure is neither constant nor uniform over the surface of the manikin/garment. Under these conditions, the results are expected to have more variability than carefully controlled bench scale tests. In addition, the garment is not constrained to be a flat surface but is allowed to have a natural drape on the manikin. The effect these variables have on a garment can be seen in several ways: ignition and burning of the garment and heraldry, sagging or shrinkage in all directions after flaming, hole generation, smoke generation and structural failure of seams. Many of these failures rarely appear in the bench scale testing of the materials because they are a result of garment design variables, interaction between material properties and design variables, construction techniques and localized exposure conditions that are more severe.

Fit of the garment on the manikin is important. Thus variations in garment design and how the manikin is dressed by the operator can influence the test results. A test garment or specimen size is selected by the laboratory from the size range provided by the manufacturer to fit the laboratory's manikin. Experience suggests that testing a garment one size larger than the standard will reduce the total energy transferred and percentage body burn by about 5 %.

This document is not designed to measure material properties directly, but to evaluate the interaction of material behaviour and garment design. One can compare relative material behaviour by making a series of test garments out of different materials using a common pattern. The performance of the complete garments will not necessarily be ranked in the same order as might be obtained when the materials are tested using ISO 9151. Correlations between small scale tests and results from single-layer garments have been examined^[15].

Most manikins do not have sensors on the hands and feet, but it is possible to assess some aspects of hand protection depending upon the specific design of the hands. The head, however, does contain heat flux sensors. The reason for this is that many outer garments include an integral hood, but not gloves or footwear. Tests for gloves and footwear are covered by other ISO documents for specific end uses.

The protection offered by the test specimens is evaluated through quantitative measurements and observations. Heat flux sensors fitted to the manikin are used to measure the energy transferred to the manikin surface during the data-gathering period. This information can be reported directly (this document) or used to calculate the nature, location and extent of the damage that would occur to human skin from the exposure (see ISO 13506-2).

References ^[16] and ^[17] give details of manikin and sensor construction, data acquisition, computer software requirements, flame exposure chamber and fuel and delivery system. They also suggest numerical techniques that can be used to carry out the calculations required.

The ISO/TC 94, SC 13 and SC 14 committees and European Committee for Standardization (CEN TC 162) specify the method described in this document as an optional part in the fire fighter standards ISO 11999-3 and EN 469^[11], and as an optional part in the industrial heat and flame protective clothing standard ISO 11612. The National Fire Protection Association (NFPA) specifies a test method similar to the one described in this document as part of a certification process for garments (see NFPA 2112^[13]).

Protective clothing against heat and flame —

Part 1:

Test method for complete garments — Measurement of transferred energy using an instrumented manikin

1 Scope

This document specifies the overall requirements, equipment and calculation methods to provide results that can be used for evaluating the performance of complete garments or protective clothing ensembles exposed to short duration flame engulfment.

This test method establishes a rating system to characterize the thermal protection provided by single-layer and multi-layer garments made of flame resistant materials. Any material construction such as coated, quilted or sandwich can be used. The rating is based on the measurement of heat transfer to a full-size manikin exposed to convective and radiant energy in a laboratory simulation of a fire with controlled heat flux, duration and flame distribution. The heat transfer data are summed over a prescribed time to give the total transferred energy.

For the purposes of this test method, the incident heat flux is limited to a nominal level of 84 kW/m^2 and limited to exposure durations of 3 s to 12 s dependant on the risk assessment and expectations from the thermal insulating capability of the garment. The results obtained apply only to the particular garments or ensembles, as tested, and for the specified conditions of each test, particularly with respect to the heat flux, duration and flame distribution.

This test method requires a visual evaluation, observation and inspection on the overall behaviour of the test specimen during and after the exposure as the garment or complete ensemble on the manikin is recorded before, during and after the flame exposure. Visuals of the garment or complete ensemble on the manikin are recorded (i.e. video and still images) before, during and after the flame exposure. This also applies to the evaluation of protection for the hands or the feet when they do not contain sensors. For the interfaces of ensembles tested, the test method is limited to visual inspection. The effects of body position and movement are not addressed in this test method.

The heat flux measurements can also be used to calculate the predicted skin burn injury resulting from the exposure (see ISO 13506-2).

This test method does not simulate high radiant exposures such as those found in arc flash exposures, some types of fire exposures where liquid or solid fuels are involved, nor exposure to nuclear explosions.

NOTE 1 This test method provides information on material behaviour and a measurement of garment performance on a stationary upright manikin. The relative size of the garment and the manikin and the fit of the garment on the shape of the manikin have an important influence on the performance.

NOTE 2 This test method is complex and requires a high degree of technical expertise in both the test setup and operation.

NOTE 3 Even minor deviations from the instructions in this test method can lead to significantly different test results.