



SLOVENSKI STANDARD
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Varovalna obleka pred učinki toplote in ognja - 2. del: Predvidevanje nastanka poškodb kože zaradi opeklin - Zahteve za izračun in primeri preskusov (ISO/DIS 13506-2:2023)

Protective clothing against heat and flame - Part 2: Skin burn injury prediction - Calculation requirements and test cases (ISO/DIS 13506-2:2023)

Schutzkleidung gegen Hitze und Flammen - Teil 2: Vorhersage von Verbrennungsverletzungen der Haut - Berechnungsanforderungen und Prüffälle (ISO/DIS 13506-2:2023)

Habillement de protection contre la chaleur et les flammes - Partie 2: Prédiction de blessure par brûlure de la peau - Exigences de calculs et cas d'essa (ISO/DIS 13506-2:2023)

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Protective clothing against heat and flame —

Part 2: Skin burn injury prediction — Calculation requirements and test cases

*Vêtements de protection contre la chaleur et les flammes —**Partie 2: Prédiction de blessure par brûlure de la peau — Exigences de calculs et cas d'essai*

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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).

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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 second edition of ISO 13506-2, cancels and replaces the first edition of ISO 13506-2:2017, which has been technically revised.

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, which can be made into a garment or protective clothing ensemble for testing on a manikin fire exposure system.

This document is a companion document to ISO 13506-1. The data gathered by tests according to ISO 13506-1 are used as input for this calculation.

In the test method standard ISO 13506-1, a stationary, upright, adult-sized manikin is dressed in a garment or protective clothing ensemble 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. Thermal energy sensors are fitted to the surface of the manikin. The output from the sensors is used to calculate 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 will no longer be rising. The information obtained from the calculation of skin burn injury prediction (see [Annex B](#)) can be used to assist in evaluating the performance of the garment or protective clothing ensemble under the test conditions. It can also be used as a model-based tool to estimate the extent and nature of potential skin damage resulting from the exposure of the test garment.

Fit of the garment or protective clothing ensemble on the manikin is important. Thus, variations in garment or protective clothing ensemble design and how the manikin is dressed by the operator may influence the test results and skin burn injury prediction. Experience suggests that testing a garment one size larger than the standard can reduce the percentage of predicted body burn by up to 5 %.

ISO 13506-1 uses the calculated skin injury information in the calculation of the Thermal Manikin Performance Factor.

The ISO/TC 94/SC 13 and SC 14 committees and the 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 and as an optional part in the industrial heat and flame protective clothing standard ISO 11612.

The National Fire Protection Association standard NFPA 2112^[5] specifies ASTM F1930-18^[6], which is a test method similar to the one described in ISO 13506-1 and which contains skin burn injury prediction calculations similar to the one described in this document.

Protective clothing against heat and flame —

Part 2:

Skin burn injury prediction — Calculation requirements and test cases

1 Scope

This document provides technical details for calculating predicted burn injury to human skin when its surface is subject to a varying heat flux, such as may occur due to energy transmitted through and by a garment or protective clothing ensemble exposed to flames. A series of test cases are provided against which the burn injury prediction calculation method is verified. It also contains requirements for the *in situ* calibration of the thermal energy sensor — skin injury prediction system for the range of heat fluxes that occur under garments.

The skin burn injury calculation methods as presented in this test method do not include terms for handling short wavelength radiation that may penetrate the skin. The latter include arc flashes, some types of fire exposures with liquid or solid fuels, and nuclear sources.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

<https://standards.iteh.ai/catalog/standards/sist/a7812f6a-9c88-40ee-8525-ec0d00000000/iso-tr-11610>, *Protective clothing — Vocabulary*

ISO/DIS 13506-1:—, *Protective clothing against heat and flame — Part 1: Test method for complete garments — Measurement of transferred energy using an instrumented manikin*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13506-1 and ISO/TR 11610 and the following apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

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3.1 burn injury

damage which occurs at various depths within human tissue due to elevated temperatures resulting from heat transfer to the surface

Note 1 to entry: Burn injury in human tissue occurs when the tissue is heated and kept at an elevated temperature (>44 °C) for a critical period of time. In this document, it is assumed that skin has three layers: the epidermis, which is the tough outer layer, the dermis, which is the layer below the epidermis, and the subcutaneous tissue (adipose), which is the fatty layer of tissue deeper than the dermis. In this document, it is assumed that the thicknesses of the layers are the same everywhere on the human body. Variations in thickness that occur with age, location and sex are not included. The severity of damage, referred to as predicted first-, second-, or third-degree (or partial thickness or full thickness) burn injury, depends upon the magnitude of the elevated temperature above 44 °C and the time during which it remains at or above 44 °C.

3.1.1 first-degree burn injury first-degree burn

burn damage in which only the superficial part of the epidermis has been injured

Note 1 to entry: The skin turns red, but does not blister or actually burn through. First-degree burn injury is reversible. In this document, the time for a predicted first-degree burn injury to occur is indicated when the value of $\Omega = 0,53$ [see [Formula \(3\)](#)] at a skin depth of 75×10^{-6} m (75 μ m), i.e. at the epidermis/dermis interface.

3.1.1.1 first-degree burn injury area first-degree burn area

sum of the areas represented by heat flux sensors for which only a calculated first-degree burn injury is predicted to occur

3.1.2 second-degree burn injury second-degree burn partial thickness burn

burn damage in which the epidermis and a varying extent of the dermis are burned, but the entire thickness of the dermis is not usually destroyed and the subcutaneous layer is not injured

Note 1 to entry: Second-degree burn injury is more serious than first-degree burn injury, resulting in complete necrosis (living cell death) of the epidermis layer, usually accompanied with a blister, but is reversible especially if the affected area is small. In this document, the time for a predicted second-degree burn injury to occur is indicated when the value of $\Omega = 1,0$ [see [Formula \(3\)](#)] at a skin depth of 75×10^{-6} m (75 μ m), i.e. at the epidermis/dermis interface.

3.1.2.1 second-degree burn injury area second-degree burn area

sum of the areas represented by heat flux sensors for which a calculated second-degree burn injury is the most severe injury predicted to occur

3.1.3 third-degree burn injury third-degree burn full thickness burn

burn damage which extends through the dermis, into or beyond the subcutaneous tissue

Note 1 to entry: Third-degree burn injury is not reversible. In this document, the time for a predicted third-degree burn injury to occur is indicated when the value of $\Omega = 1,0$ [see [Formula \(3\)](#)] at a skin depth of $1\,200 \times 10^{-6}$ m (1 200 μ m), i.e. at the dermis/subcutaneous interface.

3.1.3.1**third-degree burn injury area**
third-degree burn area

sum of the areas represented by the heat flux sensors for which a calculated third-degree burn injury is predicted to occur

3.1.4**total burn injury area**
total burn area

sum of the areas represented by the heat flux sensors for which at least a second-degree burn injury is predicted to occur

3.2**omega value** Ω

skin injury parameter, the value of the damage integral [see [Formula\(3\)](#)], which indicates predicted *burn injury* ([3.1](#)) at specific skin depths and temperature regimes

3.3**pain area**

sum of the areas represented by the heat flux sensors for which pain is predicted to occur

3.4**time to pain**

time taken for the pain receptors to reach 43,2 °C

Note 1 to entry: In this document, the pain receptors are located 195×10^{-6} m (195 μ m) below the surface of the skin.

4 General

oSIST prEN ISO 13506-2:2023

The calculation of predicted skin burn injury is a desirable result when used to compare the relative performance of protective clothing using test methods that measure heat to the manikin surface for a defined thermal energy exposure. This document outlines the calculation method that shall be used for this purpose when conducting the tests as described in ISO 13506-1. ISO 13506-1 specifies the method for the measurement of the energy transfer, which can be used as a basis for evaluation of the relative thermal protective performance of the test specimen. The performance is a function of both the materials of construction and design and of fit of clothing onto the test manikin. The average exposure heat flux is 84 kW/m² with durations from 3 s to 20 s.

Predicted burn injury determined in this test method uses a simplified mathematical model that does not directly translate into actual human skin burn injury for any exposure test conditions. The model is based on measurements on human volar forearms (Stoll and Greene^[8]).

The test specimen is placed on an adult-size manikin (see ISO 13506-1, clause 5.1) at ambient atmospheric conditions and exposed to a laboratory simulation of a fire with controlled heat flux, duration and flame distribution. The test procedure, data acquisition, result calculations and preparation of the test report are performed with computer hardware and software programs.

Thermal energy transferred through the test specimen and from the test specimen to the surface of the manikin during and after the exposure is measured by heat flux sensors positioned in the surface of the manikin. The amount of heat varies with time. The method specified in this document uses the heat flux measurements of ISO 13506-1 to calculate the predicted time to pain for each thermal energy sensor, the first, second- and third-degree burn injury areas, and the total burn injury area resulting from the exposure. Identification of the test specimen, test conditions, comments and remarks about the test purpose and response of the test specimen to the exposure are recorded and are included as part of the test report. The total energy transferred and/or the predicted skin burn injury area, and the way the test specimen responds to the flame exposure are indicators for the performance of the test specimen