SLOVENSKI STANDARD

oSIST prEN ISO 18640-2:2016

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Varovalna obleka za gasilce - Fiziološki vpliv - 2. del: Določanje fiziološke toplotne obremenitve, ki jo povzroča uporaba varovalne obleke za gasilce (ISO/DIS 18640-2:2016)

Protective clothing for fire-fighters- physiological impact - Part 2: Determination of physiological heat load caused by protective clothing worn by firefighters (ISO/DIS 18640 -2:2016)

Schutzkleidung für die Feuerwehr - Physiologische Wärmebelastung - Teil 2: Bestimmung der physiologischen Wärmebelastung ausgelöst durch von Feuerwehrleuten getragene Schutzkleidung (ISO/DIS 18640-2:2016)

Vêtements de protection pour sapeurs-pompiers - Effet physiologique - Partie 2: Détermination de la charge thermo-physiologique provoquée par les vêtements de protection portés par les sapeurs-pompiers (ISO/DIS 18640-2:2016)

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ICS:

13.220.10	Gašenje požara	Fire-fighting
13.340.10	Varovalna obleka	Protective clothing

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DRAFT INTERNATIONAL STANDARD
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Protective clothing for fire-fighters- physiological impact —

Part 2: Determination of physiological heat load caused by protective clothing worn by firefighters

Titre manque

ICS: 13.340.10

ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

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Foreword

SO (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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 18640-2 was prepared by Technical Committee ISO/TC 94, *Personal safety - Protective clothing and equipment*, Subcommittee SC 14, *Fire-fighters' personal equipment*.

ISO 18640 consists of the following parts, under the general title *Protective clothing for fire-fighters — Physiological impact*:

Part 1: Measurement of coupled heat and mass transfer with the sweating TORSO

Part 2: Determination of physiological heat load caused by protective clothing worn by fire-fighters

Introduction

Protective clothing for (structural) firefighting may have a serious physiological impact[Text1),Text2)] on the wearer and a serious implication on the acute physical condition of the wearer during activities with increased metabolic heat production [1, 2]. Protective clothing impedes heat exchange by sweat evaporation and therefore maintenance of a constant core body temperature is no longer possible. This fact increases the risk to suffer from heat stress and reduces working time of fire fighters. If this is identified in a risk assessment, it is important that (thermal) physiological parameters are obtained to ensure the suitability of the protective clothing chosen under the expected conditions of use. The assessment of the thermo-physiological impact of protective clothing provides important information about the applicability for different kinds of activities taking place in various conditions. In part 1 of this standard, relevant physical parameters of protective clothing are measured with a Sweating Torso. Standard Sweating Torso measurements provide physical parameters about combined heat and mass transfer (part 1 of this standard). Based on these parameters, the thermo-physiological impact of protective clothing is estimated and the maximum exposure time for defined environmental conditions and a defined activity protocol are predicted either by a statistical model or thermal human simulator (THS) measurements. The results of the standard Sweating Torso measurements are applied to a validated statistical model to predict the physiological effects due to the use of that particular protective clothing. In THS measurements the sweating Torso is coupled to a physiological model which allows physiological data to be obtained directly in relation to a defined exposure scenario.

The purpose for this standard is to check for aspects of protective clothing performance that cannot be determined by tests described in other standards. The aim of this standard is to quantify the physiological effects of protective garments (without additional clothing layers) for (structural) firefighting under a relevant standardized simulated scenario for fire fighters by predicting the physiological load. This standard specifies a minimum level of performance requirements during a defined firefighting scenario under defined environmental conditions using the assessed fire fighters' protective clothing by calculation of the maximum allowable work time before an inappropriately high core temperature will be reached.

NOTE: Depending on the PPE being worn, underclothing may be required, e.g. fire fighter structural clothing. The purpose of testing without underwear is to ensure repeatability.

1) Nunneley reported a significant physiological burden due to the protective clothing upon the wearer, both in the form of increased metabolic rate and reduced heat dissipation [1]

2) Taylor showed that the relative influence of the clothing on oxygen cost was at least three times that of the breathing apparatus [2]

Protective clothing for fire-fighters- physiological impact —

Part 2:
Determination of physiological heat load caused by protective clothing worn by firefighters

1 Scope

This international standard provides the general principles of a test method for evaluating the physiological impact of complete garments or protective clothing ensembles in a simulated activity under defined relevant conditions for fire fighters.

This International Standard is intended to be used to describe the thermo-physiological impact of protective clothing but **not** the risk for heat stress due to actual fire conditions. The results of this test method can be used as elements of a risk assessment with respect to heat stress or cardiovascular load.

Note The presently used evaluation methods are only validated for structural firefighting garments

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 6330, *Textiles — Domestic washing and drying procedures for textile testing*

ISO 11092, *Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

ISO 7243:1989, *Hot environments — Estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature)*

ISO 7933:2004, *Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain*

EN 469 2014*Protective clothing for firefighters - Performance requirements for protective clothing for firefighting*

ISO 11612, *Protective clothing — Clothing to protect against heat and flame — Minimum performance requirements*

EN 15614*Protective clothing for firefighters - Laboratory test methods and performance requirements for wildland clothing*

ISO 16073, *Wildland firefighting personal protective equipment — Requirements and test methods*

ISO 15384, *Protective clothing for firefighters — Laboratory test methods and performance requirements for wildland firefighting clothing*

prEN 16689*Protective clothing for protection of firefighters during technical rescue operations – performance requirements*

ISO/DIS 11999, *PPE for firefighters - Test methods and requirements for PPE used by firefighters who are at risk of exposure to high levels of heat and/or flame while fighting fires occurring in structures - Part 1: General*

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

ISO/CD 18640-1 *Protective clothing for fire-fighters- physiological impact – Part 1: Measurement of coupled heat and mass transfer with the sweating TORSO*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply, in addition to the terms and definitions in ISO 18640-1.

3.1 Cooling delay (CD)

Time delay (and temperature rise) until the effect of evaporation cooling will be detected in a measurement phase with simulated activity (elevated heating power) and sweating.

3.2 Maximum allowable work duration (MAWD)

Value in minutes calculated according to a statistical model (see also Annex A) predicting the time to reach heat stress based on the definitions of this standard.

3.3 Condensed sweat water, condensation, moisture stored in clothing system

Fraction of supplied sweat water in active phase with sweating which remains in clothing system assessed with Torso weight difference (taking into account potentially dripped off water).

3.4 Core body temperature (T_{co})

The temperature of deep structures of the (human) body, such as the liver, as compared to that of peripheral tissues, mostly measured in the gastrointestinal tract.

3.5 Evaporated sweat water

Fraction of supplied sweat water which evaporated in active phase with sweating. Difference between supplied sweat water and weight difference of Torso (condensed/stored sweat water).

3.6 Experimental phases / phase profile

A test as defined in part 1 of this standard is segmented in multiple phases. Each phase of the test simulates a specific situation with defined temperature or heating power and sweat rate settings.

3.7 Firefighting scenario

A set of environmental conditions, a defined workload and a defined exposure time relevant for a fire fighters' task.

3.8 Heart rate

The number of heartbeats per unit of time, usually per minute.

3.9 Heat storage

Heat accumulation in the body affected by metabolic heat produced, external heat load and heat dissipated from the body.

3.10 Initial cooling (IC)

Time (and temperature) at which initial cooling ends in a measurement phase simulating activity with sweating.

3.11 Mean skin temperature (mT_{sk})

The mean temperature of the outer surface of the (human) body measured at several locations of the skin.

3.12 Moisture uptake

Moisture stored in clothing system derived from weight course of Torso during measurement.

3.13 Sustained cooling (SC)

Steady state of cooling in a measurement phase simulating activity with sweating.

3.14 Spacer

Simulation of air layer. Air layer influence the overall thermal resistance and moisture transport. A spacer may be used to simulate a defined air layer.

3.15 Sweating Torso

Upright standing cylindrical test apparatus, simulating the human trunk with thermal guards on the upper and lower end (see part 1 of this standard). The apparatus is equipped with heating foils, sweating nozzles, a multi-layer shell (simulation of the skin layers).

3.16 Sweat rate

Supply of nano-pure water to simulate sweating. There are 54 nozzles on the surface of the Torso used to distribute water on the surface of the measurement cylinder. The amount of released water is controlled by a defined height difference between storage tank, weight measurement and calibrated opening time and interval of the valves.

3.17 Thermal resistance (R_{ct})

Measure for thermal resistance in m^2.K/W. R_{ct} is calculated at steady state from the difference between Torso surface and ambient temperature, the surface area of the device and the heating power needed to maintain the temperature difference.

3.18 THS Thermal Human Simulator measurement (THS)

Measurements on the sweating Torso where the device is coupled with a validated physiological model. The control software for the Torso exchanges data with the physiological model, within an iterative control loop, to simulate realistic human response during a defined activity starting from thermally neutral conditions.

3.19 Torso surface temperature

Average temperature on the surface of the measurement area (0.43 m^2) of the Torso device. Temperature is assessed with a thin nickel wire applied to the surface or a similar method allowing registering the average surface temperature. There are two wires attached to the Torso surface which allows differing between the front and back side of the device (important for measurements with wind)

4 Symbols (and abbreviated terms)

R_{ct}	Thermal resistance in m^2.K/W assessed in steady state condition (phase 1 of measurement)
T_{co}	Core body temperature
mT_{sk}	Mean skin temperature
CD	Cooling delay (time in min until cooling effect of perspiration becomes apparent)
IC	initial cooling (initial rate of surface temperature reduction in °C/h observable right after CD was reached
SC	sustained cooling (rate of surface temperature change in °C/h (or min?) resulting from cooling effect of perspiration and wet insulation of the fabric)
PC	Post cooling (assessed by finding the time (h) of change in surface temperature decrease rate (°C/h) after cessation of physical activity induced when the condensed moisture which was still in the clothing system has dried out)
MAWD	Maximum allowable work duration (in minutes) based on a statistical model or THS measurements
THS	Thermal human simulator: Measurement on Torso coupled with a thermo-physiological model.

5 Evaluation method

5.1 General

Physical parameters about thermal properties of protective clothing resulting from standard Torso measurements do not contain any information about the thermo-physiological responses of the wearer for various firefighters' scenarios. Physiological data can be deducted either by coupling the Torso system to a physiological model or by applying a statistical model based on the physical data from standard Torso measurements.

A statistical model was developed to calculate a value for the maximum allowable work duration (MAWD) according to thermal characteristics of the clothing. This model was validated based on human subject trials and Torso measurements (see also Annex B).

5.2 Firefighters' scenario's

Firefighters are dealing with a variety of tasks and challenges. Therefore there are many scenarios which would have to be considered. In order to ensure a maximum level of comparison a limited number of firefighter scenarios are described in Annex E.

5.2.1 Fire fighter scenario for the statistical model

For the purpose of this standard a scenario was selected which reflects a moderate firefighter activity (see also Annex E) and which was used as the basis for the statistical model.

The applied firefighter work load scenario is defined as follows:

— Ambient condition is set to 28°C air temperature and 65% relative humidity.

— No radiation is present and a unidirectional wind speed of 1 m/s is applied.

— Physical activity is set to 6 Met (350 W/m^2 metabolic rate, 285 W/m^2 metabolic heat production)

— Initial condition of the human body is assumed to be thermo-neutral (T_{co} = 36.8°C; mT_{sk} = 34.2 °C).

