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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Live working – Protective clothing against the thermal hazards of an electric arc – Part 2: Requirements

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CONTENTS

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LIVE WORKING – PROTECTIVE CLOTHING AGAINST THE THERMAL HAZARDS OF AN ELECTRIC ARC –

Part 2: Requirements

FOREWORD

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International Standard IEC 61482-2 has been prepared by IEC technical committee 78: Live working.

This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) new definition for *ELIM*, *ATPV* and *EBT* as used in accordance with IEC 61482-1-1:–;
b) new requirements for the thermal stability of the intermediate layers;
c) additional material requirement for volume resistance;
d) new test procedure for the thermal resistance of sewing threads;
e) new symbol for marking.

The text of this standard is based on the following documents:

FDIS	Report on voting
78/1205/FDIS	78/1228/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Terms defined in Clause 3 are given in *italic* print throughout this standard.

A list of all parts of the IEC 61482 series, published under the general title *Live working – Protective clothing against the thermal hazards of an electric arc,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document has been prepared in accordance with the requirements of IEC 61477.

The products designed and manufactured according to this document contribute to the safety of the users, provided they are used by skilled persons, in accordance with safe methods of work and the instructions for use.

The product covered by this document may have an impact on the environment during some or all stages of its life cycle. These impacts can range from slight to significant, be of short-term or long-term duration, and occur at the global, regional or local level.

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LIVE WORKING – PROTECTIVE CLOTHING AGAINST THE THERMAL HAZARDS OF AN ELECTRIC ARC –

Part 2: Requirements

1 Scope

This part of IEC 61482 is applicable to *protective clothing* used in work where there is the risk of exposure to an *electric arc hazard*.

This document specifies requirements and test methods applicable to *materials* and *garments* for *protective clothing* for electrical workers against the thermal hazards of an *electric arc* ~~based on~~.

~~– relevant general properties of the textiles, tested with selected textile test methods, and~~

~~– arc thermal resistance properties, such as~~

- ~~the arc rating of materials (ATPV or E_{BT50}), when tested with an open electric arc under defined laboratory conditions according to IEC 61482-1-1, or~~
- ~~the arc protection class of materials and garments (Class 1 or Class 2), when tested with a directed and constrained electric arc under defined laboratory conditions according to IEC 61482-1-2.~~

~~Requirements of this standard do not address electric shock hazards. The present standard is applicable in combination with standards covering such hazards.~~

~~NOTE 1 If conductive fibres are used in the construction of the garments the risk for electric shock hazard should be considered.~~

~~This standard does not contain requirements for the protection of head, hands and feet.~~

~~NOTE 2 Requirements and tests to cover these hazards are under development.~~

~~Requirements of this standard do not cover the electric arc hazards of electric shock, noise, UV emissions, pressure shrapnel, hot oil, the consequences of physical and mental shock and the toxic influences.~~

~~NOTE 3 The standard is applicable in combination with standards covering such hazards.~~

Electric shock hazard is not covered by this document, which is applicable in combination with standards covering such hazards.

Other effects than the thermal effects of an *electric arc* like noise, light emissions, pressure rise, hot oil, electric shock, the consequences of physical and mental shock or toxic influences are not covered by this document.

Protection of eyes, face, head, hands and feet against *electric arc hazard* is not covered by this document.

NOTE Requirements and tests to cover *electric arc hazards* to these parts of the body are under development.

Protective clothing for work intentionally using an *electric arc*, e.g. arc welding, plasma torch, is not covered by this document.

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.

IEC 60417, *Graphical symbols for use on equipment* (available at: http://www.graphical-symbols.info/equipment)

IEC 61318~~:2007~~, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 61340-2-3:2016, *Electrostatics – Part 2-3: Methods of test for determining the resistance and resistivity of solid materials used to avoid electrostatic charge accumulation*

IEC 61477, *Live working – Minimum requirements for the utilization of tools, devices and equipment*

IEC 61482-1-1:–[1], *Live working – Protective clothing against the thermal hazards of an electric arc – Part 1-1: Test methods – Method 1: Determination of the arc rating (ELIM, ATPV and/or ~~E_{BT50}~~ EBT) of ~~flame resistant materials for~~ clothing materials and of protective clothing using an open arc*

IEC 61482-1-2~~:2007~~, *Live working – Protective clothing against the thermal hazards of an electric arc – Part 1-2: Test methods – Method 2: Determination of arc protection class of material and clothing by using a constrained and directed arc (box test)*

~~ISO 3175-2, *Textiles – Professional care, drycleaning and wetcleaning of fabrics and garments – Part 2: Procedure for testing performance when cleaning and finishing using tetrachloroethene*~~

ISO 3146, *Plastics – Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods*

ISO 3758, *Textiles – Care labelling code using symbols*

ISO 5077, *Textiles – Determination of dimensional change in washing and drying*

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

ISO 13688:~~1998~~ 2013, *Protective clothing – General requirements*

ISO 13934-1, *Textiles – Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13937-2, *Textiles – Tear properties of fabrics – Part 2: Determination of tear force of trouser-shaped test specimens (Single tear method)*

ISO 13938-1, *Textiles – Bursting properties of fabrics – Part 1: Hydraulic method for determination of bursting strength and bursting distension*

[1] Under preparation. Stage at time of publication: IEC CDV 61482-1-1:2017.

ISO 13938-2, *Textiles – Bursting properties of fabrics – Part 2: Pneumatic method for determination of bursting strength and bursting distension*

~~ISO 14116:2007, *Protective clothing – Protection against heat and flame – Limited flame spread materials, material assemblies and clothing*~~

ISO 15025~~:2000~~, *Protective clothing – Protection against ~~heat and~~ flame – Method of test for limited flame spread*

ISO 17493:2016, *Clothing and equipment for protection against heat – Test method for convective heat resistance using a hot air circulating oven*

ISO 30023, *Textiles – Qualification symbols for labelling workwear to be industrially laundered*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318 and the following apply.

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

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

3.1.1
arc protection class
APC
<*electric arc* testing> category of *arc thermal protection* of a *material* and/or product tested in accordance with the box test (APC 1 or APC 2)

Note 1 to entry: The *arc protection class* is characterized by the test energy level of arc exposure (*arc energy* and incident energy).

Note 2 to entry: Tested *material* and/or products show *arc thermal protection* at minimum up to the *class* energy level but, in general, the actual exposure energy limit up to which the *material* and/or product provide protection is higher.

3.1.2
arc rating
<*electric arc* testing> numerical value attributed to a product, that describes its protective performance when exposed to an electric arc

Note 1 to entry: The *arc rating* can be the arc thermal performance value (*ATPV*), the *breakopen* threshold energy (*EBT*) or the *incident energy limit* (*ELIM*).

Note 2 to entry: The *arc rating* is expressed in kJ/m^2 (cal/cm^2).

3.1.3
arc thermal protection
<*electric arc* testing> degree of thermal protection offered against *electric arc* under specific arc testing conditions indicated by either *arc rating* or *arc protection class*

Note 1 to entry: For *materials*, the *arc thermal ~~performance~~ protection* is obtained from the measurement of the transmitted energy and by evaluation of other thermal parameters (burning time, hole formation, melting).

Note 2 to entry: For *garments*, the *arc thermal ~~performance~~ protection* is obtained by evaluation of thermal parameters (burning time, hole formation, melting) of the *material*(s) from which the *garment* is made and of the functioning of ~~fasteners~~ the closures and accessories.

~~[Definition 3.5 of IEC 61482-1-2:2007]~~

3.1.4
arc thermal performance value
ATPV
~~in *arc* testing, the incident energy on a material or a multilayer system of materials that results in a 50 % probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second degree skin burn injury based on the Stoll curve, without breakopen~~

~~NOTE ATPV is expressed in kJ/m^2 or kW·s/m^2 (cal/cm^2).~~ ~~2)~~

~~[Definition 3.1.4 of IEC 61482-1-1]~~

<*electric arc* testing> numerical value of incident energy attributed to a product that describes its thermal properties of attenuating (reducing) a heat flux generated by an *electric arc*

Note 1 to entry: The *ATPV* of a *material* or material assembly is calculated using logistic regression analysis applied to the data points obtained from testing a set of test specimens. It is the value of incident energy at which the heat transfer through the test specimens is enough to reach the Stoll criteria with 50 % probability.

Note 2 to entry: The *ATPV* attributed to a *garment* or garment assembly is either equal to or lower than the *ATPV* of the *material* or material assembly of which it is made, depending on whether the tested specimen(s) fulfil also additional visual design and performance assessment criteria.

3.1.5
breakopen threshold energy
~~E_{BT50}~~ ***EBT***
~~incident energy on a fabric or material that results in a 50 % probability that sufficient heat transfer through the tested specimen is predicted to cause the tested specimen to break open~~

~~NOTE The breakopen threshold energy is expressed in kJ/m^2 or kW·s/m^2 (cal/cm^2).~~ ~~3)~~

~~[Definition 3.1.8 of IEC 61482-1-1, modified]~~

<*electric arc* testing> numerical value of incident energy attributed to a product that describes its breakopen properties when exposed to heat flux generated by an *electric arc*

Note 1 to entry: The *EBT* of a *material* or material assembly is calculated using logistic regression analysis applied to the data points obtained from testing a set of test specimens. It is the value of incident energy at which breakopen occurs with 50 % probability.

Note 2 to entry: The *EBT* attributed to a *garment* or garment assembly is either equal to or lower than the *EBT* of the *material* or material assembly of which it is made, depending on whether the tested specimen(s) fulfil also additional visual design and performance assessment criteria.

~~**3.4**~~
~~**clothing**~~
~~assembly of garments worn by workers~~

3.1.6
electric arc
self-maintained gas conduction for which most of the charge carriers are electrons supplied by primary-electron emission

Note 1 to entry: During live working, the *electric arc* is generated by gas ionization arising from an unintentional electrical conducting connection or breakdown between live parts or a live part and the earth path of an electrical installation or an electrical device. During testing, the *electric arc* is initiated by the blowing of a fuse wire.

~~2) Correlation 1 cal/cm^2 = 41,868 kJ/m^2; 1 kJ/m^2 = 0,023885 cal/cm^2.~~

~~3) Correlation 1 cal/cm^2 = 41,868 kJ/m^2; 1 kJ/m^2 = 0,023885 cal/cm^2.~~

[SOURCE: IEC 60050-121:1998, 121-13-12, modified – Note 1 to entry has been added to refer specifically to live working and arc testing.]

3.1.7
electric arc hazard
potential harm from an energy release from an *electric arc* usually caused by a short circuit or equipment failure in electrotechnical work

Note 1 to entry: An *electric arc hazard* exists when live electrical conductors or parts are exposed and when they are inside an item of equipment, even when guarded or enclosed, if a worker is interacting with the equipment in a way which could cause an *electric arc*. Under normal operating conditions, enclosed energized equipment that has been properly designed, installed and maintained is not likely to pose an *electric arc hazard*.

Note 2 to entry: Documents such as NFPA 70E, IEEE 1584, ISSA Guide, and DGUV-I 203-77 help to assess hazards from the practical perspective.

Note 3 to entry: The hazards may include thermal effects, noise, pressure wave effects, ejected parts effects, molten metal, optical and other effects. Different PPE (personal protective equipment) may be required to protect from different effects. It is important that the risk assessment consider all the potential effects.

3.1.8
garment
single item of clothing which ~~may~~ can consist of single or multiple layers of *material*

3.1.9
garment system
garment assembly for which a specific *arc rating* or *arc protection class* is attributed after having performed an arc test

3.1.10
hardware
non-fabric items forming part of or optional extras in a *garment*

3.1.11
incident energy limit
ELIM

<*electric arc testing*> numerical value of incident energy attributed to a product, below which there is no data point with the amount of heat transmitted through the product reaching the Stoll criteria or with the product exhibiting breakopen

Note 1 to entry: The $ELIM$ of a *material* or material assembly is calculated from data points obtained from testing a set of test specimens, which are also used for the determination of the $ATPV$ and/or EBT.

Note 2 to entry: The $ELIM$ attributed to a *garment* or garment assembly is either equal to or lower than the $ELIM$ of the *material* or material assembly of which it is made, depending on whether the tested specimen(s) fulfil also additional visual design and performance assessment criteria.

3.1.12
material
~~fabric or other substances of which the garment is made, this may consist of single or multiple layers~~
substances, excluding *hardware*, of which an item of clothing is made

[SOURCE ISO 11612:2015, 3.13]

3.1.13
open arc
<*electric arc* testing> *electric arc* between two vertically opposing electrodes intended to provide an equal distribution of emitted energy around the centre line formed by the electrodes and where the emitted energy is not directed by means of any physical constraints (e.g. enclosure, wall)

3.1.14
protective clothing
clothing which covers or replaces personal clothing, ~~and which is designed to provide clothing which covers or replaces personal clothing~~ and which is designed to provide protection against one or more hazards

[~~Definition 3.4 of ISO 13688:1998~~ SOURCE: ISO/TR 11610:2004, 3.178]

~~**3.9**~~
~~**Stoll curve**~~
~~curve of thermal energy and time produced from data on human tissue tolerance to heat and used to predict the onset of second-degree burn injury~~

~~[Definition 3.29 of IEC 61482-1-2:2007]~~

~~**3.10**~~
~~**test current**~~
~~$I_{arc,\ class}$~~
~~prospective short-circuit current of the electric test circuit (predicted current), characterising a test class, r.m.s. value (symmetrical AC component)~~

~~NOTE Test current is expressed in A.~~

~~[Definition 3.30 of IEC 61482-1-2:2007]~~

3.2 Symbols and units

APC	arc protection class	1 or 2
ATPV	arc thermal performance value	kJ/m^2 or cal/cm^2
EBT	breakopen threshold energy	kJ/m^2 or cal/cm^2
ELIM	incident energy limit	kJ/m^2 or cal/cm^2

NOTE 1 kJ/m^2 = 1 kW·s/m^2 = 0,1 J/cm^2 = 0,023 885 cal/cm^2

1 cal/cm^2 = 41,840 kJ/m^2 = 41,840 kW·s/m^2

4 Requirements

4.1 General

General requirements for *protective clothing* against the thermal hazard of an electric arc which are not specifically covered in this document shall be in accordance with ISO 13688.

4.2 Design requirements for protective clothing

~~The garment shall be designed in a way, that they do not influence or hinder the wearer performing work.~~

~~Garments protecting the upper part of the body shall have long sleeves.~~

~~Fasteners of the garment shall be designed in a way that the opening function is still present after being exposed to an accidental arc.~~

~~Thread, accessories and closures used in garment construction shall not contribute to the severity of the injuries to the wearer in the event of a momentary electric arc and related thermal exposure.~~