

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Travaux sous tension – Vêtements de protection contre les dangers thermiques
d'un arc électrique –
Partie 2: Exigences**

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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Part 2: Requirements**

**Travaux sous tension – Vêtements de protection contre les dangers thermiques
d'un arc électrique –
Partie 2: Exigences**

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**LIVE WORKING –
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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

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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*.

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, *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 EBT) of clothing materials and of protective clothing using an open arc*

IEC 61482-1-2, *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 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 13688:2013, *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*

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

ISO 15025, *Protective clothing – Protection against 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>

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

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/m² (cal/cm²).

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 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 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 the closures and accessories.

3.1.4

arc thermal performance value

ATPV

<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

EBT

<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.

3.1.6**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.

[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 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**

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 protection against one or more hazards

[SOURCE: ISO/TR 11610:2004, 3.178]

3.2 Symbols and units

| | | |
|-------------|-------------------------------|--|
| <i>APC</i> | arc protection class | 1 or 2 |
| <i>ATPV</i> | arc thermal performance value | kJ/m ² or cal/cm ² |
| <i>EBT</i> | breakopen threshold energy | kJ/m ² or cal/cm ² |
| <i>ELIM</i> | incident energy limit | kJ/m ² or cal/cm ² |

NOTE 1 kJ/m² = 1 kW·s/m² = 0,1 J/cm² = 0,023 885 cal/cm²

1 cal/cm² = 41,840 kJ/m² = 41,840 kW·s/m²

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4 Requirements**4.1 General**

IEC 61482-2:2018

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

Garments protecting the upper part of the body shall have sleeves which extend to provide full coverage to the wrists and shall provide coverage up to the neck. *Garments* protecting the lower part of the body shall provide full coverage from the waist to the ankles.

Closures of the *garment* shall be designed in a way that the opening function is still present after being exposed to an arc when tested according to 5.2.5.

Accessories (e.g. labels, badges, retro-reflective material) and closures used in *garment* construction shall not contribute to the severity of the injuries to the wearer in the event of an *electric arc* and related thermal exposure when the clothing is tested according to the garment test in 5.4. Separation of the closure shall not occur.

Sewing thread utilized in the construction of *garments* shall be made of an inherently flame-resistant fibre and shall not melt when tested according to 5.2.5. Threads in seams that have no influence on protection, e.g. hems, pocket seams, need not be flame resistant.

No uncovered outside metal parts shall be permitted in the clothing. *Hardware* penetrating the outer *material* of the *garment* shall not be exposed to the innermost surface of the *garment*.

All exposed parts of a *garment* shall be made of *arc thermal protection materials*. In case different *materials* are used for the front and back of the *garment*, the exact information shall be given in the instructions for use where the weakest area is located (e.g. by means of a drawing of the *garment* including dimensions and warning indication).

NOTE 1 The user can carry out a hazard risk assessment to determine the level of protection needed. Documents such as NFPA 70E, IEEE 1584, ISSA Guide, and DGUV-I 203-77 help to assess hazards from the practical perspective.

For *garments* covering torso and arms, the front side and the sleeves all around the arms and over their complete length shall fulfil the same *arc thermal protection*.

For *garments* covering legs, the front over the complete length shall fulfil the same *arc thermal protection*.

For coveralls, both requirements for *garments* covering torso and arms and *garments* covering legs shall be fulfilled.

Where protection is provided by an outer two-piece suit, it shall be determined that, when correctly sized for the wearer, an overlap between the jacket and trousers remains when one standing wearer firstly fully extends both arms above the head and then bends over until the fingertips touch the ground when tested according to 5.2.1.

If a manufacturer makes claims for a *garment system* as arc thermal *protective clothing*, then this *garment system* shall be tested and shall fulfil the requirements of this document.

NOTE 2 If the user is wearing *garments* from different manufacturers as arc thermal *protective clothing*, he is responsible for assessing how the assembly fulfils the requirements of this document.

4.3 General material requirements

4.3.1 Heat resistance

Materials shall not ignite, melt or shrink by more than 5 % when tested according to 5.3.1.

4.3.2 Volume resistance

Materials of the *garment* using electrically conductive fibres, except for *garments* meeting IEC 60895, when tested according to 5.3.2, shall have a volume resistance of at least 10⁵ Ω.

4.3.3 Limited flame spread of material

4.3.3.1 Classification of limited flame spread

All *materials* shall achieve a specified limited flame spread index when tested according to 5.3.3 and shall be classified according to Tables 1 to 4.

4.3.3.2 Single-layer material

If a single-layer *material* is used in the *garment*, this *material* shall fulfil the requirements given in Table 1.

Table 1 – Single-layer material

| Property | Requirement |
|----------------|--|
| Flame spread | No specimen shall permit any part of the lowest boundary of any flame to reach the upper or either vertical edge. |
| Flaming debris | No specimen shall give flaming or molten debris. |
| Hole formation | No specimen shall give hole formation of 5 mm or greater in any direction. |
| Afterglow | Afterglow time shall be ≤ 2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of 4.3.3.2, shall not be regarded as afterglow. |
| Afterflame | Afterflame time shall be ≤ 2 s. |

4.3.3.3 Multi-layer material

If the *garment* consists of multiple layers, all outer-layer and innermost-layer *materials* shall fulfil the requirements given in Table 2.

Table 2 – Outer and innermost layer materials

| Property | Requirement |
|----------------|---|
| Flame spread | No specimen shall permit any part of the lowest boundary of any flame to reach the upper or either vertical edge. |
| Flaming debris | No specimen shall give flaming or molten debris. |
| Hole formation | No specimen shall give hole formation of 5 mm or greater in any direction. |
| Afterglow | Afterglow time shall be ≤ 2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of 4.3.3.3, shall not be regarded as afterglow. |
| Afterflame | Afterflame time shall be ≤ 2 s. |

In addition, if the *garment* consists of more than two layers, each intermediate layer, depending on the intention declared by the manufacturer to contribute either to the arc thermal protection or not, shall fulfil Table 4 or Table 3, respectively.

Table 3 – Intermediate layer material not intended for arc thermal protection

| Property | Requirement |
|----------------|---|
| Flame spread | No specimen shall permit any part of the lowest boundary of any flame or hole to reach the upper or either vertical edge. |
| Flaming debris | No specimen shall give flaming or molten debris. |
| Afterglow | Afterglow time shall be ≤ 2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of 4.3.3.3, shall not be regarded as afterglow. |

NOTE Such intermediate layers are only used for specific protection other than *arc thermal protection*, for example protection against liquid penetration and/or wind.

Table 4 – Intermediate layer material intended for arc thermal protection

| Property | Requirement |
|----------------|---|
| Flame spread | No specimen shall permit any part of the lowest boundary of any flame to reach the upper or either vertical edge. |
| Flaming debris | No specimen shall give flaming or molten debris. |
| Hole formation | No specimen shall give hole formation of 5 mm or greater in any direction. |
| Afterglow | Afterglow time shall be ≤ 2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of 4.3.3.3, shall not be regarded as afterglow. |
| Afterflame | Afterflame time shall be ≤ 2 s. |

NOTE Such intermediate layers are designated to increase the *arc thermal protection*.