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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

IEC 61482-2:2018-05 RLV(en)

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

Part 2: Requirements

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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- withdrawn,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.

This document does not include requirements and test provisions for the manufacturers of the product, or recommendations to the users of the product for environmental improvement. However, all parties intervening in its design, manufacture, packaging, distribution, use, maintenance, repair, reuse, recovery and disposal are invited to take account of environmental considerations.

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/m² or kW·s/m² (cal/cm²).~~ ~~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/m² or kW·s/m² (cal/cm²).~~ ~~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/cm² = 41,868 kJ/m²; 1 kJ/m² = 0,023885 cal/cm².~~

~~3) Correlation 1 cal/cm² = 41,868 kJ/m²; 1 kJ/m² = 0,023885 cal/cm².~~

[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.~~

~~No exposed external metal shall be permitted in the clothing. If internal metal and/or melting parts (e.g. fasteners, buttons, and accessories) are used they shall be covered to the inside to avoid skin contact.~~

~~All parts of a garment shall be made of arc thermal resistant materials. In case different materials are used e.g. for the front and back the exact information shall be given where the weaker area is located (e.g. by means of a drawing of the garment including dimensions and warning indication).~~

~~The front side of the garment and the complete sleeves (all around the arms and over the complete length of the arms) of the garment (e.g. jackets) shall fulfil the same arc thermal resistance requirements. If due to comfort requirements the garment is not produced of the same materials in all areas then this shall be clearly stated in the instructions for use.~~

~~NOTE 1 These requirements are also valid for garments protecting the lower part of the body (e.g. trousers, chaps, leggings).~~

~~Sewing thread utilized in the construction of garments shall be made of an inherently flame-resistant fibre and shall not melt when tested at a temperature of 260 °C in accordance with ISO 17493. There are many seams in a garment that have no influence on protection, e.g. hems, pocket seams, etc. The sewing thread there need not be flame resistant.~~

~~During its service life, protective clothing shall keep its arc thermal properties when cleaned according to the instructions for use.~~

~~If a single 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 standard.~~

~~NOTE 2 If the user is wearing a garment system (e.g. jacket + shirt) from different manufacturers as arc thermal protective clothing, then this garment system should be tested to determine how the system fulfils the requirements of this standard.~~

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 10^5 Ω.

4.3.3 Limited flame spread of material

4.3.3.1 Classification of limited flame spread ~~index~~

~~All materials claiming compliance with this standard shall achieve a specified limited flame spread index when tested in accordance with ISO 15025 Procedure A (see 5.3.1) and classified according to ISO 14116.~~

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 ~~limited flame spread index 3~~ 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 a multi-layer material is used in the garment, the following requirements shall be fulfilled:~~

~~– all outer layer and innermost layer materials shall fulfil the limited flame spread index 3,~~

~~– all middle layers shall fulfil in minimum the flame spread index 1.~~

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*.	

4.3.4 Mechanical properties of ~~woven~~ outer material

4.3.4.1 Tear resistance

Woven and laminated outer *material* shall have a tear resistance of at least 15 N for weight higher than 220 g/m^2 or at least 10 N for weight ~~within 150 g/m^2 and~~ of 220 g/m^2 or below in the machine and the cross directions when tested according to ~~ISO 13937-2~~ 5.3.4.1.

4.3.4.2 Tensile strength

Woven and laminated outer *material* shall have a tensile strength of at least 400 N for weight higher than 220 g/m^2 or at least 250 N for weight ~~within 150 g/m^2 and~~ of 220 g/m^2 or below in the machine and the cross directions when tested according to ~~ISO 13934-1~~ 5.3.4.2.

4.3.4.3 Burst strength ~~of knitted outer material~~

The knitted outer *material* shall have a burst strength of at least ~~200~~ 100 kPa while using a 50 cm^2 test area, or of at least 200 kPa while using a 7,3 cm^2 test area when tested according to ~~ISO 13938-1~~ 5.3.4.3.

4.3.5 Dimensional change of material due to ~~laundering and/or dry~~ cleaning ~~of outer material~~

~~The woven outer material shall have a dimensional change according to ISO 5077 not exceeding ± 3 % in the machine and the cross directions tested according to 5.3.4.~~

~~The knitted outer material shall have a dimensional change according to ISO 5077 not exceeding ± 5 % tested according to 5.3.4.~~

The woven and laminated outermost and innermost *material* shall have a dimensional change not exceeding ± 3 % in either length or width direction when tested according to 5.3.5.

The knitted outermost and innermost *material* shall have a dimensional change not exceeding ± 5 % when tested according to 5.3.5.

NOTE To verify the shrinkage of each single layer in a multi-layer assembly, it can be helpful to test the assembly closed by sewing around the edges.

4.4 Arc thermal ~~resistance~~ protection requirements

~~The protective clothing covered by this standard shall have certain resistance properties to the thermal effects of an electric arc.~~

~~Two international test methods have been developed to provide information on the resistance of clothing to the thermal effects of electric arcs. Each method gives different information.~~

~~To be in accordance with this standard, a product shall be evaluated by using IEC 61482-1-1 or/and IEC 61482-1-2. Depending on the needs, the users will specify for one test method or the other.~~

~~NOTE 1 Depending of the characteristics of the network and equipment (e.g. medium voltage or low voltage, available short-circuit current, protection characteristics) and the location on the network where the live working is performed (e.g. close to the substation or not), the possible energy in the arc is different. The users should evaluate the needs in term of thermal resistance to electric arc taking these elements into consideration.~~

~~Material test as well as garment test shall be performed.~~

~~For garment certification both the material and garment shall fulfil the requirements. Previously certified materials do not require retesting for the garment certification.~~

~~When tested according to IEC 61482-1-1, the protective clothing made of the tested material shall be assigned a corresponding ATPV of the material. A protective clothing will demonstrate a minimum arc thermal resistance, if the ATPV is at least 167,5 kJ/m^2 (4 cal/cm^2). The higher is the ATPV value, the better is the thermal resistance under higher incident arc energy (higher current value, longer exposure time).~~

~~NOTE 2 The necessary ATPV is to be determined by risk analysis. Guidance for the appropriate selection of an ATPV is provided in other separate standards, e.g. in IEEE 1584 and NFPA 70E.~~

~~In case that no ATPV can be determined, the E_{BT50} shall be determined and assigned to the tested material. The minimum E_{BT50} demonstrated by the material shall be at least 167.5 kJ/m^2 (4 cal/cm²).~~

~~When tested according to IEC 61482-1-2, the protective clothing made of the tested material shall be assigned a Class 1 or a Class 2 depending of the test conditions and the resulting arc thermal protection. A protective clothing will demonstrate a minimum arc thermal protection, if it passes the Class 1 test. A Class 2 indicates a higher arc thermal resistance.~~

~~NOTE 3 The classification of IEC 61482-1-2 does not intend to evaluate the resistance of protective clothing to electric arcs having arc energies above 318 kJ ± 44 kJ.~~

~~If other material(s) are used for the back (rear or dorsum) they shall fulfil at least the requirements of Class 1 according to IEC 61482-1-2 or a minimum ATPV rating of 167,5 kJ/m^2 (4 cal/cm^2) according to IEC 61482-1-1. The label of the garment shall reflect the lowest of these ratings.~~

~~If a garment is made of different materials or different layers (e.g. only the front part of the garment is made with more material layers), then this shall be clearly stated in the instructions for use.~~

4.4.1 General

The *protective clothing* shall have protection properties against the thermal effects of an *electric arc*.

Two test methods have been developed to provide information on the protection of clothing from the thermal effects of *electric arcs*. Each method gives different information.

The test shall be performed on the *material* and the finished *garment* by using test methods IEC 61482-1-1 or/and IEC 61482-1-2 and both the *material* and *garment* shall fulfil the requirements. Depending on the needs, either or both standards can be specified.

NOTE Depending of the characteristics of the power system and equipment (e.g. medium voltage or low voltage, available short-circuit current, protection characteristics) and the location in the system where the live working is performed (e.g. close to the substation or not), the possible energy in the arc is different. These elements influence the needs in terms of the required thermal resistance to *electric arc*.

If other *material*(s) are used for the back (rear or dorsum), they shall fulfil at least a minimum *arc rating* according to IEC 61482-1-1 or the minimum requirements of Class 1 according to IEC 61482-1-2. The label of the *garment* shall reflect the lowest of these ratings.

4.4.2 Arc rating

When tested according to IEC 61482-1-1, the *protective clothing* made of the tested *material* shall have an *arc rating*. A manufacturer may assign a lower *arc rating* value to a *material* or *protective clothing* than the value resulting from testing.

Protective clothing shall have a minimum *arc thermal protection*, where the $ELIM$ is at least 130 kJ/m^2 (3,2 cal/cm^2) and where the lower value of $ATPV$ and EBT is at least 167 kJ/m^2 (4 cal/cm^2). In case only either $ATPV$ or EBT can be determined, this value shall be at least 167 kJ/m^2 (4 cal/cm^2).

Due to the limitations of test apparatus at very high energy arcs, no *arc rating* above 4 186 kJ/m^2 (100 cal/cm^2) shall be assigned to *garments*.

NOTE 1 The higher the *arc rating*, the better the *arc thermal protection* under higher incident arc energy (higher current value, longer exposure time).

NOTE 2 According to safety regulations, the necessary *arc rating* is determined by risk analysis. Guidance for the appropriate selection of an *arc rating* is provided in other separate standards, e.g. in IEEE 1584 and NFPA 70E.

4.4.3 Arc protection classes

When tested according to IEC 61482-1-2, the *protective clothing* made of the tested *material* shall be assigned an APC 1 or an APC 2 depending on the test conditions and the resulting *arc thermal protection*. *Protective clothing* shall demonstrate a minimum *arc thermal protection* of APC 1. An APC 2 indicates a higher *arc thermal protection*.

NOTE The necessary *arc protection class* is determined by risk analysis. Guidance for the appropriate selection of the *arc protection class* is provided in other separate guidelines, e.g. in ISSA Guide and DGUV-I 203-077.

4.5 Marking

~~Each garment for which compliance with this standard is claimed~~ *Protective clothing* shall at least be marked with information as outlined in Clause A.1. The marking shall meet the general requirements of marking in ISO 13688.

If a *garment* is made of different *materials* or different numbers of layers (e.g. only the front part of the *garment* ~~is made with more material~~ consists of multiple layers), the label of the *garment* shall indicate the lowest of the *arc ratings* and/or *arc protection class*.

If a *garment* manufacturer claims protection by a *garment~~s~~ system* (e.g. jacket with a shirt, removable lining of a jacket), the marking shall make the correct use clear for the end user. The marking of a *garment system* shall mention each item of the system, identified by a clear reference code, and, if determined, the obtained *arc thermal protection*, as well as the *arc ratings* and/or *arc protection class* of the whole *garment system*.

NOTE In a *garment system*, it may be possible to write "not determined" for *arc thermal protection* in the marking of the single item.

4.6 Instructions for use

Protective clothing shall be supplied with the manufacturer's written instructions for use and care.

These instructions shall be prepared in accordance with Clause A.2, and with the general provisions given in IEC 61477 and ISO 13688.

Additional information for use and maintenance are given in Clause A.2.

5 Tests

5.1 General

5.1.1 Overview

This document provides testing provisions to demonstrate compliance of the product with the requirements of Clause 4. These testing provisions are primarily intended to be used as type tests for validation of the design input. Where relevant, alternative means (calculation, examination, tests, etc.), are specified within the test subclauses mentioned in Table B.1 for the purpose of *protective clothing* having completed the production phase.

Tests of requirements which are not specifically covered in this document shall be in accordance with ISO 13688.

A list of type tests with reference to corresponding subclauses is given in Table B.1.

5.1.2 Test conditions

The conditioning atmosphere for the tests according to 5.3 shall be the temperature 20 °C ± 2 °C and relative humidity 65 % ± 5 % for 24 h.

5.1.3 Pre-treatment ~~- Laundering and/or dry~~ by cleaning

~~For arc testing and flame testing of materials or garments (5.3.1 and 5.4.1) and for testing according to 5.3.2.1, 5.3.2.2, 5.3.3 and 5.3.4, the specimen shall be washed five times in a front-loading horizontal drum machine, using 1 g/l of detergent 3 in soft water and finally dried in accordance with the procedures of ISO 6330. Washing shall be carried out by procedure 2A (60° C ± 3° C) and drying by procedure E (tumble drying) unless otherwise specified in the care labeling.~~

For testing heat resistance (5.3.1), volume resistance (5.3.2), flame testing (5.3.3), testing of mechanical properties (5.3.4) and arc testing of *material* and *garments* (5.4.1), the test specimens shall be pre-treated by cleaning.

The cleaning shall be in line with the manufacturer's instructions on the basis of standardized processes. The tests shall be carried out after five cleaning cycles (a cleaning cycle is one wash and one dry cycle).

If washing is permitted as well as dry cleaning, then the specimen shall only be washed. Products which are labelled as dry cleaning only shall be dry cleaned ~~five times in accordance with ISO 3175-2~~ only.

NOTE Manufacturer's instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797, ISO 3175-2 or equivalent standardized processes for washing.

5.2 Tests of design requirements for protective clothing

5.2.1 General

The compliance with the requirements of 4.2 shall be verified by visual inspection or other appropriate means for validation.

For interfaces/overlap, conformity shall be checked by visual inspection including an assessment of fit and physical measuring when the appropriate size of clothing is donned by a wearer.

5.2.2 Garment construction and workmanship

If applicable, the *garment* or *garment system* construction shall be inspected visually for the following design properties:

– long sleeves which extend to provide full coverage to the wrists;

~~– no uncovered internal metal and/or melting parts,~~

~~– all parts made of arc thermal resistance material,~~

– full coverage from the waist to the ankles;

– coverage up to the neck;

– no uncovered outside metal parts;

– no *hardware* parts that penetrate from the outside to the innermost surface;

– identical *arc thermal* ~~performance~~ *protection* of front side and complete sleeves.

If the *garment* or *garment system* is made of different *materials*, it shall be ~~inspected~~ checked by inspection whether the instructions for use clearly indicate the weakest area (drawing, warning indication).

5.2.3 Size designation and ergonomics

The conformity to size designation shall be checked by measurement. The conformity to ergonomics (design appropriate to not hinder the wearer performing work) shall be checked by inspection when the appropriate size of clothing is ~~donned~~ put on by a wearer (human test person).

NOTE Procedures for checking of ergonomic features of *protective clothing* are described in ~~Annex D of ISO 11612~~ Annex C of ISO 13688:2013.

5.2.4 Ageing

~~The test according to procedure A of ISO 15025 (see 5.3.1) shall also be made after the maximum laundering and/or dry cleaning cycles indicated by the manufacturer in line with the manufacturer's instructions on the basis of standardized processes.~~

~~NOTE Manufacturer instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797 or equivalent, as standardized processes for cleaning.~~

~~The test shall be considered as passed if the aged material keeps the same classification index as determined under 5.3.1 with after pre-treatment according to 5.1.2.~~

When the manufacturer's instructions for use give a maximum number of cleaning cycles, the requirements for limited flame spread (4.3.3) shall be met after the maximum number of cleaning cycles indicated by the manufacturer. If the maximum number of cleaning cycles is not specified, the test (5.3.3) shall be carried out after five cleaning cycles. Number of cycles used shall be reflected in the manufacturer's instructions for use (Clause A.2). The cleaning process shall be in line with the manufacturer's instructions, on the basis of standardized processes.

5.2.5 Threads~~, accessories~~ and closures

Sewing thread ~~used for the outer- and/or innermost materials~~ utilized in the construction of *garments* shall be tested according to ISO ~~17493~~ 3146 Method B at a temperature of 260 °C ± 5 °C.

~~The opening and closing function of fasteners shall be tested by practical performance test.~~

The function of the closures shall be tested by practical performance test after completion of the arc thermal test in 5.4. A *garment* shall be considered as fulfilling the requirement if the opening of the closure by a person does not last more than 30 s.

5.3 Tests of general material requirements

5.3.1 Heat resistance

The test shall be carried out according to ISO 17493:2016, 8.1 after pre-treatment according to 5.1.3 at a temperature of $180\,^{+8}_{0}$ °C for an exposure time of $300\,^{+15}_{0}$ s. *Materials* can be either tested separately or as assembled in the *garment*.

NOTE To verify the shrinkage of each single layer in a multi-layer assembly, it can be helpful to test the assembly closed by sewing around the edges.

5.3.2 Volume resistance

The test shall be carried out according to IEC 61340-2-3:2016, 8.2.3 after pre-treatment according to 5.1.3.

NOTE Test according to EN 1149-2 may show comparable results.

5.3.3 Limited flame spread of material

~~The test shall be carried out with the number and arrangement of specimens according to ISO 15025, Procedure A after pre-treatment according to 5.1.2. If the garment consists of several layers, each material layer shall be tested separately.~~

The test shall be carried out according to ISO 15025, Procedure A after pre-treatment according to 5.1.3.

If the *garment* consists of a single layer, specimens shall be tested by applying the flame to the outer surface of the *material*.

If the *garment* consists of multiple layers, specimens of the *material* assembly shall be tested by applying the flame both to the surface of the outer material of the *garment* and to the innermost surface of the *garment*.

5.3.4 Mechanical properties of ~~woven~~ outer material

5.3.4.1 Tear resistance

~~The test shall be carried out with the number and arrangement of specimens according to ISO 13937-2. If the garment consists of several layers, only the outer material shall be tested.~~

For woven and laminated outer *material*, the test shall be carried out according to ISO 13937-2. If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.4.2 Tensile strength

~~For woven material the test shall be carried out with the number and arrangement of specimens according to ISO 13934-1 (strip). If the garment consists of several layers only the outer material shall be tested.~~

For woven and laminated outer *material*, the test shall be carried out according to ISO 13934-1 (strip). If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.4.3 Burst strength ~~of knitted outer material~~

~~For knitted material the test shall be carried out with the number and arrangement of specimens according to ISO 13938-1. If the garment consists of several layers only the outer material shall be tested.~~

For knitted outer *material*, the test shall be carried out according to either ISO 13938-1 or ISO 13938-2. If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.5 Dimensional change due to laundering and/or dry cleaning ~~of outer material~~

~~The test procedure shall be carried out with the number and arrangement of specimens in accordance with ISO 5077.~~

The test procedure shall be carried out in accordance with ISO 5077 after five cleaning cycles (a cleaning cycle is one wash and one dry cycle) according to manufacturer's instructions.

NOTE Manufacturer's instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797 or equivalent, as standardized processes for cleaning.

5.4 Tests of arc thermal ~~resistance~~ protection requirements

5.4.1 Type tests

At least one of the two possible standard tests according to 4.4 shall be performed.

– IEC 61482-1-1 (~~ATPV test~~ method 1, both ~~method~~ procedure A and ~~method~~ procedure B).

  Testing according to IEC 61482-1-1:– provides the $ELIM$, $ATPV$ or EBT_{50}.

– IEC 61482-1-2 (~~box test~~ method 2, both *material* box test ~~method~~ procedure and *garment* box test ~~method~~ procedure).

  Testing according to IEC 61482-1-2 makes it possible to decide whether the requirements of Class 1 or Class 2 are fulfilled.

The arc exposure shall be applied to the outer surface of the test specimens.

If the *garment* or the *garment system* consists of layers intended for *arc thermal protection* (see Tables 1, 2 and 4), the material test shall be done on test specimens consisting of all layers.

If the *garment* or the *garment system* consists of multiple layers and there are intermediate layers not intended for *arc thermal protection* (see Table 3), the *material* test shall be done on test specimens consisting of all layers which are on top of the outermost intermediate layer that is not intended for *arc thermal protection*.

5.4.2 Alternative means to arc thermal ~~resistance~~ protection test to fulfil conformity assessment of protective clothing having completed the production phase

There is no real alternative test to the *arc thermal ~~resistance~~ protection* test (destructive test) after completing the production phase for checking the conformity to the associated requirement.

Nevertheless the *garment* manufacturer shall prove that he has followed the same documented assembly procedure with identical components (*materials* and accessories) as per the type tested *garment*. The *material* manufacturer shall prove that he has followed the same documented manufacturing process as per the type tested *material*.

5.5 Marking

5.5.1 Visual inspection

It shall be checked by visual inspection whether the requirements of 4.5 are fulfilled.

5.5.2 Durability of marking

The marking shall be rubbed for 15 s ± 1 s with a water-soaked lint-free cloth and then be rubbed for 15 s ± 1 s with a lint-free cloth soaked with isopropanol (CH_3-CH(OH)-CH_3).

NOTE It is not within the ~~duty~~ scope of ~~an employer~~ this document to ensure that the relevant legislation and safety requirements for the use of this chemical are complied with in their entirety.

The test shall be considered as passed if the marking is still easily legible and the label has not curled or become detached.

5.6 Instructions for use

It shall be checked by visual inspection whether the requirements of 4.6 are fulfilled.

6 Conformity assessment of protective clothing having completed the production phase

For conducting the conformity assessment during the production phase, IEC 61318 shall be used in conjunction with this document.

Annex C provides the classification of defects and identifies the associated tests applicable for follow-up of production of *protective clothing* intended to comply with this document. A rationale for this classification is given in Annex D.

7 Modifications

Any modification of the *material* from which the *garment* is made, as well as any modification of the design, shall require the type tests to be repeated, in whole or in part (if the degree of modification so justifies), and shall require a change in *garment* marking and instructions for use if needed.

Annex A
(normative)

Marking and instructions for use

A.1 Marking

Each *garment* or *garment system* complying with this document shall have a marking label which shall contain at least the following items of marking:

– name, trade mark or other means of identification of the manufacturer or of its authorized representative;

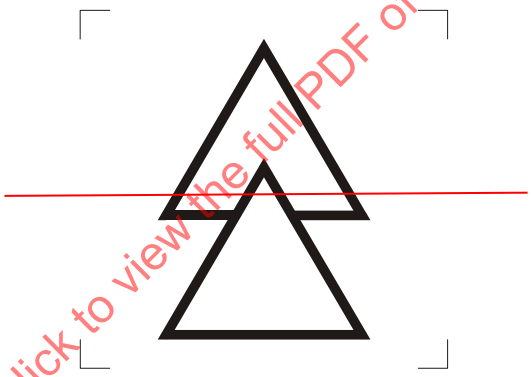
– designation of the product type, commercial name or code;

– size designation according to Clause 6 of ISO 13688:2013;

– care labelling in accordance with ISO 3758 and/or ISO 30023;

– ~~symbol IEC 60417-5216 (2002-10) – Suitable for live working; double triangle – and, adjacent to the symbol, the number of the relevant IEC standard (IEC 61482-2) and the level of arc protection;~~

~~NOTE The exact ratio of the height of the figure to the base of the triangle is 1,43. For the purpose of convenience, this ratio can be between the values of 1,4 and 1,5.~~



~~**IEC 61482-2**~~
~~ATPV or E_{BT50} = xxx cal/cm^2~~
~~or~~
~~Class 1 or Class 2~~

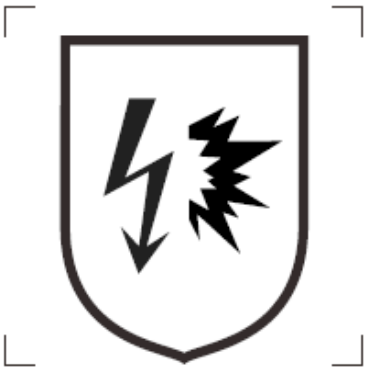
~~or~~

~~**IEC 61482-2**~~
~~ATPV or E_{BT50} = xxx cal/cm^2~~
~~and~~
~~Class 1 or Class 2~~

– symbol IEC 60417-6353:2016-02 – Protection against the thermal effect of the electric arc – and, adjacent to the symbol, the number of the relevant IEC standard (IEC 61482-2) and the *arc thermal protection* in the form of *arc rating* (*ELIM* and/or the lower value of either *ATPV* or *EBT*) and/or *arc protection class* (*APC* 1 or *APC* 2).

NOTE 1 The exact ratio of the height of the figure to the base is 1,43:1. For the purpose of convenience, this ratio can be between the values of 1,4:1 and 1,5:1.

NOTE 2 The text in the boxes below the symbol are examples.



IEC 61482-2
ELIM = yyy cal/cm^2
ATPV = xxx cal/cm^2

or

IEC 61482-2
APC = y

or

IEC 61482-2
ELIM = xxx cal/cm^2
APC = z

or

IEC 61482-2

undershirt ref. AAA: not determined
jacket ref. BBB: *ATPV* = xxx cal/cm^2 / APC = y
parka ref. CCC: *ELIM* = xxx cal/cm^2 / APC = y

Garment system: *ATPV* = xxx cal/cm^2 / APC = z

The marking of a *garment system* shall mention each item of the system, identified by a clear reference code and, if determined, the obtained *arc thermal protection*, as well as the *arc ratings* and/or *arc protection class* of the whole *garment system*.

NOTE 3 For the end user it may be helpful to have the pictograms also on the outside.

A.2 Instructions for use

Protective clothing shall be supplied to the customer with information written at least in the official language(s) of the country of destination. All information shall be unambiguous. It shall include at least the following:

– name and full address of the manufacturer and/or authorized representative;
– product designation;
– number of this document (IEC 61482-2) with the year of publication (four digits);
– pictograms, information and explanation about the type of arc test (~~ATPV/E_{BT50} or box test classification or both~~ *arc rating* or *arc protection class*);
– information on sizing;
– information to the user that
  • the environmental conditions and the risks at the working site shall be regarded;
  • deviations from the parameters in this document may result in more severe conditions;
  • *protective clothing* shall be worn in the closed state;
  • *protective clothing* according to this document is not intended to be used as electrical insulating *protective clothing* and does not provide protection against electrical shock;

- *protective clothing* that becomes contaminated with grease, oil, or flammable liquids or combustible materials should not be used;
- *protective clothing* should be cleaned when necessary;
- *protective clothing* that is damaged to the extent that its protective qualities are impaired (e.g. holes in the garment, not functioning closures) should not be used;

– information to the user

- about the protective level of all *garments* and of ~~protective clothing~~ the *garment system*;
- if the *garment* is made of different *materials* (~~see 4.2~~ e.g. for the front and back), by means of a drawing of the *garment* including dimensions and warning indication;
- that for full body protection~~, the protective clothing shall be worn in the closed state and other~~ suitable additional protective equipment (helmet with protective face screen, protective gloves and footwear (boots)) shall be used;
- that other *garments* worn together with *protective clothing* and dirty *protective clothing* can reduce the protection;
- that damaged *garments* should be repaired or replaced. In the event of tearing, such damaged clothing should not be repaired; repairing is only allowed in accordance with the manufacturer's instructions;
- that no *garments* like shirts, undergarments or underwear ~~should be used which melt under arc exposures,~~ made of, for example, polyamide, polyester or acryl fibres which melt under arc exposures, should be used;

– care instructions in accordance with ISO 3758 and/or ISO 30023;

~~– cleaning and repair instructions (e.g. warning: tears should not be repaired by user; a flammable (not flameproof) thread or heat-reactivatable piece likely to melt would be very dangerous in the event of exposure to flame);~~

– repair instructions (e.g. warnings: repairs shall not impair the performance of the clothing; repair only with identical *material* and by suitably qualified companies; do not repair it yourself);

– storage instructions (e.g. store in dry and dust-free conditions; no storage under intensive light exposure).

Annex B
(normative)

Type tests

A list of type tests with reference to corresponding subclauses is given in Table B.1.

Table B.1 – List of type tests

Type of test	Subclauses	
	Requirements	Tests
Tests on *materials*		
Heat resistance **Volume resistance** **Limited flame spread** ~~(classification of the materials)~~ **Ageing** ~~(of the garment)~~	4.3.1 4.3.2 4.3.3 4.2	5.3.1 5.3.2 5.3.3 5.2.4
Mechanical properties Tear resistance Tensile strength Burst strength Dimensional change	 4.3.4.1 4.3.4.2 4.3.4.3 4.3.5	 5.3.4.1 5.3.4.2 5.3.4.3 5.3.5
Arc thermal ~~resistance~~ protection ~~(ATPV test method A or Material box test)~~ *Arc rating* (Procedure A) *Arc protection class* (Material box test)	4.4.1 4.4.2 4.4.3	5.4.1
Tests on *garments*		
Design *Garment* construction and workmanship Size designation and ergonomics Threads~~, accessories,~~ and closures	4.2	5.2.1 5.2.2 5.2.3 5.2.5
Limited flame spread (verification of the correct classification of the different layers)	4.3.3.2 4.3.3.3	5.2.1
Arc thermal ~~resistance~~ protection ~~(ATPV test method B or Garment box test)~~ *Arc rating* (Procedure B) *Arc protection class* (Garment box test)	4.4.1 4.4.2 4.4.3	5.4.1
Marking General requirements of ISO 13688 Presence and correctness of the specified marking Durability of the marking	4.5	5.5 5.5.1 5.5.1 5.5.2
Instructions for use	4.6	5.6

Annex C
(normative)

Classification of defects

Annex C was developed to ~~address~~ classify the types of defect of *protective clothing* against the thermal hazards of an electric arc having completed the production phase (critical, major and minor) in a consistent manner (see IEC 61318). For each requirement identified in Table C.1, both the type of defect and the associated tests are specified.

The manufacturer shall test the materials and garments for certification and at a frequency to ascertain the protective performance for critical defects (see 5.4.2).

Table C.1 – Classification of defects and associated requirements and tests

~~Requirements~~		~~Type of defect~~			~~Test subclauses~~
		~~Critical~~	~~Major~~	~~Minor~~	
~~Requirements on garments (the unit of production is a garment)~~					
~~4.2~~	~~**Design of garments**~~ ~~Garment construction and workmanship~~ ~~Size designation and ergonomics~~ ~~Thread, findings, closures~~ ~~Ageing~~	~~X~~ ~~X [a]~~	~~X~~	~~X~~	~~5.2.1~~ ~~5.2.2~~ ~~5.2.4~~ ~~5.2.3~~
~~4.4~~	~~**Arc thermal resistance**~~ ~~ATPV test method B or Garment box test~~	~~X~~			~~5.4.2~~
~~4.5~~	~~**Marking**~~ ~~General requirements of ISO 13688~~ ~~Presence and correctness of the specified marking~~ ~~Durability of the marking~~	 ~~X~~		~~X~~ ~~X~~	~~5.5.1~~ ~~5.5.1~~ ~~5.5.2~~
~~4.6~~	~~**Instructions for use**~~	~~X~~			~~5.6~~
~~Requirements on materials (the unit of production is the required amount of material)~~					
~~4.3.1~~ ~~4.3.1.1~~ ~~4.3.1.2~~ ~~4.3.1.3~~	~~**Limited flame spread of material**~~ ~~Classification~~ ~~Single layer material~~ ~~Multi-layer material~~	 ~~X [a]~~ ~~X [a]~~ ~~X [a]~~			 ~~5.3.1~~ ~~5.3.1~~ ~~5.3.1~~
~~4.3.2.1~~	~~**Tear resistance of woven outer material**~~			~~X~~	~~5.3.2.1~~
~~4.3.2.2~~	~~**Tensile strength of woven outer material**~~			~~X~~	~~5.3.2.2~~
~~4.3.3~~	~~**Burst strength of knitted outer material**~~			~~X~~	~~5.3.3~~
~~4.3.4~~	~~**Dimensional change of outer material**~~			~~X~~	~~5.3.4~~
~~4.4~~	~~**Arc thermal resistance**~~ ~~(ATPV test method A or Material box test)~~	~~X~~			~~5.4.2~~

~~[a] The limited flame spread shall be assessed and documented by the material manufacturer for the lot size. The lot size is, as a minimum, the amount of material delivered to the garment manufacturer.~~

~~NOTE As a minimum unit a roll of material should be considered.~~

Requirement		Type of defect			Test subclauses
		Critical	Major	Minor	
Requirements on *materials* (the unit of production is the required amount of *material*)					
4.3.1	**Heat resistance**	X			5.3.1
4.3.2	**Volume resistance**	X			5.3.2
4.3.3 4.3.3.1 4.3.3.2 4.3.3.3	**Limited flame spread of *material*** Classification Single-layer *material* Multi-layer *material*	 X [a] X [a] X [a]			 5.3.3 5.3.3 5.3.3
4.3.4.1	**Tear resistance of outer *material***		X		5.3.4.1
4.3.4.2	**Tensile strength of outer *material***		X		5.3.4.2
4.3.4.3	**Burst strength of outer *material***		X		5.3.4.3
4.3.5	**Dimensional change**			X	5.3.5
4.4	**Arc thermal protection** *Arc rating* (Procedure A) *Arc protection class* (Material box test)	X			5.4.1
Requirements on *garments* (the unit of production is a *garment*)					
4.2	**Design** *Garment* construction and workmanship Size designation and ergonomics Ageing Threads and closures	 X X 	 X	 X 	 5.2.2 5.2.3 5.2.4 5.2.5
4.4	**Arc thermal protection** *Arc rating* (Procedure B) *Arc protection class* (Garment box test)	X			5.4.1
4.5	**Marking** General requirements of ISO 13688 Presence and correctness of the specified marking Durability of the marking	 	 X X	 X 	 5.5.1 5.5.1 5.5.2
4.6	**Instructions for use**		X		5.6
As a minimum unit, a roll of *material* should be considered. [a] Limited flame spread shall be assessed and documented by the *material* manufacturer for the lot size. The lot size is, as a minimum, the amount of material delivered to the *garment* manufacturer.					

Annex D
(informative)

Use and maintenance

D.1 Use

The garment manufacturer´s instructions for use should be followed

The garments should be inspected before each use. Protective clothing that are contaminated, or damaged to the extent their protective qualities are impaired (e.g. holes in the garment, not functioning closures), should not be used. Protective items that become contaminated with grease, oil, or flammable liquids or combustible materials should not be used.

The user should treat carefully the protective clothing.

The protective clothing shall be worn in the closed state.

No garments, such as shirts, undergarments or underwear should be used which melt under arc exposures, made of e.g. polyamide, polyester or acryl fibres.

It is strongly recommended to consider national prescriptions and regulations where protective clothing are to be used.

D.2 Maintenance

Damaged garments should be repaired (replacement of a button or other minor work) or replaced. In the event of tearing such damaged clothing should not be repaired.

Repairing is only allowed in accordance with the manufacturer's information.

Other garments worn together with protective clothing, and dirty protective clothing can reduce the protection. Although the protective clothing is designed for flame protection, contamination can reduce the protective function against electrical arc exposure. The protective clothing should therefore be cleaned when necessary.

Annex D
(informative)

Rationale for the classification of defects

Annex D provides the rationale for the classification of defects specified in Annex C. For brand new *protective clothing*, Table D.1 presents the justification for the type of defect associated with a lack of compliance with each of the requirements included in the standard.

This analysis takes into consideration that the products are used by skilled persons and in accordance with safe methods of work.

Table D.1 – Justification for the type of defect

Requirement	Justification for the associated defect specified in Annex C
Material	
Critical defects	
Heat resistance Volume resistance Limited flame spread of *material* *Arc thermal protection*	These defects are the most important aspects of *arc thermal protection*; they cannot be detected by the worker; they need to be assessed and documented by the *material* manufacturer.
Major defects	
Tear resistance	This defect can be directly detected by the worker who will not use the *protective clothing*.
Tensile strength	This defect can be directly detected by the worker who will not use the *protective clothing*.
Burst strength	This defect can be directly detected by the worker who will not use the *protective clothing*.
Minor defects	
Dimensional change	It is not likely that a shrinkage will result in a failure of the *protective clothing*.
Garments	
Critical defects	
Design of *garments*: *Garment* construction and workmanship Ageing	Wrong construction with insufficient *material* in the *garment* may be a hazard for the user. Insufficient performance of the *garment* after a certain number of care cycles may be a hazard for the user.
Arc thermal protection	Wrong construction with insufficient *material* in the *garment* may be a hazard for the user.
Major defects	
Design of *garments*: Thread and closures	With defective closures, the worker will not use the *protective clothing*.
Marking: Presence of marking Durability of the marking	Without marking, the worker will not use the *protective clothing*. With illegible marking, the worker will not use the *protective clothing*.
Instructions for use	Without instructions, the worker will not use the *protective clothing*.

Requirement	Justification for the associated defect specified in Annex C
Minor defects	
Design of *garments*: Size designation and ergonomics	It is not likely that this will result in a failure of the *protective clothing*.
Marking: General requirements of ISO 13688	General marking requirements have a minor influence on the *arc thermal protection* and are not likely to result in a failure.

Bibliography

IEC 60050-121~~:1998~~, *International Electrotechnical Vocabulary – Part 121: Electromagnetism* ~~Amendment 1:2002~~
(available at: www.electropedia.org)

IEC 60895, *Live working – Conductive clothing for use at nominal voltage up to 800 kV a.c. and ± 600 kV d.c.*

ISO 11612:~~2008~~ 2015, *Protective clothing – Clothing to protect against heat and flame – Minimum performance requirements*

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

ISO 15797, *Textiles – Industrial washing and finishing procedures for testing of workwear*

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*

NFPA 70E, *Standard for electrical safety in the workplace*

IEEE 1584, *IEEE Guide for performing arc-flash hazard calculations*

ISSA Guide, *Guideline for the selection of personal protective equipment when exposed to the thermal effects of an electric fault arc, International Social Security Association (ISSA), 711 Ed. 2, 2011, ISBN 978-3-937824-08-6*

DGUV Information 203-077, *Thermal hazards of electric fault arcs – Guideline for the selection of personal protective equipment, German Social Accident Insurance (DGUV), October 2012 (formerly: BGI/GUV-I 5188)*

IEC 61482-2

Edition 2.0 2018-05

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

IEC 61482-2:2018-05(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 2: Requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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.

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.

This document does not include requirements and test provisions for the manufacturers of the product, or recommendations to the users of the product for environmental improvement. However, all parties intervening in its design, manufacture, packaging, distribution, use, maintenance, repair, reuse, recovery and disposal are invited to take account of environmental considerations.

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/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 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

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

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 10^5 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*.	

4.3.4 Mechanical properties of outer material

4.3.4.1 Tear resistance

Woven and laminated outer *material* shall have a tear resistance of at least 15 N for weight higher than 220 g/m^2 or at least 10 N for weight of 220 g/m^2 or below in the machine and the cross directions when tested according to 5.3.4.1.

4.3.4.2 Tensile strength

Woven and laminated outer *material* shall have a tensile strength of at least 400 N for weight higher than 220 g/m^2 or at least 250 N for weight of 220 g/m^2 or below in the machine and the cross directions when tested according to 5.3.4.2.

4.3.4.3 Burst strength

The knitted outer *material* shall have a burst strength of at least 100 kPa while using a 50 cm^2 test area, or of at least 200 kPa while using a 7,3 cm^2 test area when tested according to 5.3.4.3.

4.3.5 Dimensional change of material due to cleaning

The woven and laminated outermost and innermost *material* shall have a dimensional change not exceeding ± 3 % in either length or width direction when tested according to 5.3.5.

The knitted outermost and innermost *material* shall have a dimensional change not exceeding ± 5 % when tested according to 5.3.5.

NOTE To verify the shrinkage of each single layer in a multi-layer assembly, it can be helpful to test the assembly closed by sewing around the edges.

4.4 Arc thermal protection requirements

4.4.1 General

The *protective clothing* shall have protection properties against the thermal effects of an *electric arc*.

Two test methods have been developed to provide information on the protection of clothing from the thermal effects of *electric arcs*. Each method gives different information.

The test shall be performed on the *material* and the finished *garment* by using test methods IEC 61482-1-1 or/and IEC 61482-1-2 and both the *material* and *garment* shall fulfil the requirements. Depending on the needs, either or both standards can be specified.

NOTE Depending of the characteristics of the power system and equipment (e.g. medium voltage or low voltage, available short-circuit current, protection characteristics) and the location in the system where the live working is performed (e.g. close to the substation or not), the possible energy in the arc is different. These elements influence the needs in terms of the required thermal resistance to *electric arc*.

If other *material*(s) are used for the back (rear or dorsum), they shall fulfil at least a minimum *arc rating* according to IEC 61482-1-1 or the minimum requirements of Class 1 according to IEC 61482-1-2. The label of the *garment* shall reflect the lowest of these ratings.

4.4.2 Arc rating

When tested according to IEC 61482-1-1, the *protective clothing* made of the tested *material* shall have an *arc rating*. A manufacturer may assign a lower *arc rating* value to a *material* or *protective clothing* than the value resulting from testing.

Protective clothing shall have a minimum *arc thermal protection*, where the $ELIM$ is at least 130 kJ/m^2 (3,2 cal/cm^2) and where the lower value of $ATPV$ and EBT is at least 167 kJ/m^2 (4 cal/cm^2). In case only either $ATPV$ or EBT can be determined, this value shall be at least 167 kJ/m^2 (4 cal/cm^2).

Due to the limitations of test apparatus at very high energy arcs, no *arc rating* above 4 186 kJ/m^2 (100 cal/cm^2) shall be assigned to *garments*.

NOTE 1 The higher the *arc rating*, the better the *arc thermal protection* under higher incident arc energy (higher current value, longer exposure time).

NOTE 2 According to safety regulations, the necessary *arc rating* is determined by risk analysis. Guidance for the appropriate selection of an *arc rating* is provided in other separate standards, e.g. in IEEE 1584 and NFPA 70E.

4.4.3 Arc protection classes

When tested according to IEC 61482-1-2, the *protective clothing* made of the tested *material* shall be assigned an APC 1 or an APC 2 depending on the test conditions and the resulting *arc thermal protection*. *Protective clothing* shall demonstrate a minimum *arc thermal protection* of APC 1. An APC 2 indicates a higher *arc thermal protection*.

NOTE The necessary *arc protection class* is determined by risk analysis. Guidance for the appropriate selection of the *arc protection class* is provided in other separate guidelines, e.g. in ISSA Guide and DGUV-I 203-077.

4.5 Marking

Protective clothing shall at least be marked with information as outlined in Clause A.1. The marking shall meet the general requirements of marking in ISO 13688.

If a *garment* is made of different *materials* or different numbers of layers (e.g. only the front part of the *garment* consists of multiple layers), the label of the *garment* shall indicate the lowest of the *arc ratings* and/or *arc protection class*.

If a *garment* manufacturer claims protection by a *garment system* (e.g. jacket with a shirt, removable lining of a jacket), the marking shall make the correct use clear for the end user. The marking of a *garment system* shall mention each item of the system, identified by a clear reference code, and, if determined, the obtained *arc thermal protection*, as well as the *arc ratings* and/or *arc protection class* of the whole *garment system*.

NOTE In a *garment system*, it may be possible to write "not determined" for *arc thermal protection* in the marking of the single item.

4.6 Instructions for use

Protective clothing shall be supplied with the manufacturer's written instructions for use and care.

These instructions shall be prepared in accordance with Clause A.2, and with the general provisions given in IEC 61477 and ISO 13688.

Additional information for use and maintenance are given in Clause A.2.

5 Tests

5.1 General

5.1.1 Overview

This document provides testing provisions to demonstrate compliance of the product with the requirements of Clause 4. These testing provisions are primarily intended to be used as type tests for validation of the design input. Where relevant, alternative means (calculation,

examination, tests, etc.), are specified within the test subclauses mentioned in Table B.1 for the purpose of *protective clothing* having completed the production phase.

Tests of requirements which are not specifically covered in this document shall be in accordance with ISO 13688.

A list of type tests with reference to corresponding subclauses is given in Table B.1.

5.1.2 Test conditions

The conditioning atmosphere for the tests according to 5.3 shall be the temperature 20 °C ± 2 °C and relative humidity 65 % ± 5 % for 24 h.

5.1.3 Pre-treatment by cleaning

For testing heat resistance (5.3.1), volume resistance (5.3.2), flame testing (5.3.3), testing of mechanical properties (5.3.4) and arc testing of *material* and *garments* (5.4.1), the test specimens shall be pre-treated by cleaning.

The cleaning shall be in line with the manufacturer's instructions on the basis of standardized processes. The tests shall be carried out after five cleaning cycles (a cleaning cycle is one wash and one dry cycle).

If washing is permitted as well as dry cleaning, then the specimen shall only be washed. Products which are labelled as dry cleaning only shall be dry cleaned only.

NOTE Manufacturer's instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797, ISO 3175-2 or equivalent standardized processes for washing.

5.2 Tests of design requirements for protective clothing

5.2.1 General

The compliance with the requirements of 4.2 shall be verified by visual inspection or other appropriate means for validation.

For interfaces/overlap, conformity shall be checked by visual inspection including an assessment of fit and physical measuring when the appropriate size of clothing is donned by a wearer.

5.2.2 Garment construction and workmanship

If applicable, the *garment* or *garment system* construction shall be inspected visually for the following design properties:

– long sleeves which extend to provide full coverage to the wrists;
– full coverage from the waist to the ankles;
– coverage up to the neck;
– no uncovered outside metal parts;
– no *hardware* parts that penetrate from the outside to the innermost surface;
– identical *arc thermal protection* of front side and complete sleeves.

If the *garment* or *garment system* is made of different *materials*, it shall be checked by inspection whether the instructions for use clearly indicate the weakest area (drawing, warning indication).

5.2.3 Size designation and ergonomics

The conformity to size designation shall be checked by measurement. The conformity to ergonomics (design appropriate to not hinder the wearer performing work) shall be checked by inspection when the appropriate size of clothing is put on by a wearer (human test person).

NOTE Procedures for checking of ergonomic features of *protective clothing* are described in Annex C of ISO 13688:2013.

5.2.4 Ageing

When the manufacturer's instructions for use give a maximum number of cleaning cycles, the requirements for limited flame spread (4.3.3) shall be met after the maximum number of cleaning cycles indicated by the manufacturer. If the maximum number of cleaning cycles is not specified, the test (5.3.3) shall be carried out after five cleaning cycles. Number of cycles used shall be reflected in the manufacturer's instructions for use (Clause A.2). The cleaning process shall be in line with the manufacturer's instructions, on the basis of standardized processes.

5.2.5 Threads and closures

Sewing thread utilized in the construction of *garments* shall be tested according to ISO 3146 Method B at a temperature of 260 °C ± 5 °C.

The function of the closures shall be tested by practical performance test after completion of the arc thermal test in 5.4. A *garment* shall be considered as fulfilling the requirement if the opening of the closure by a person does not last more than 30 s.

5.3 Tests of general material requirements

5.3.1 Heat resistance

The test shall be carried out according to ISO 17493:2016, 8.1 after pre-treatment according to 5.1.3 at a temperature of $180\,^{+8}_{0}$ °C for an exposure time of $300\,^{+15}_{0}$ s. *Materials* can be either tested separately or as assembled in the *garment*.

NOTE To verify the shrinkage of each single layer in a multi-layer assembly, it can be helpful to test the assembly closed by sewing around the edges.

5.3.2 Volume resistance

The test shall be carried out according to IEC 61340-2-3:2016, 8.2.3 after pre-treatment according to 5.1.3.

NOTE Test according to EN 1149-2 may show comparable results.

5.3.3 Limited flame spread of material

The test shall be carried out according to ISO 15025, Procedure A after pre-treatment according to 5.1.3.

If the *garment* consists of a single layer, specimens shall be tested by applying the flame to the outer surface of the *material*.

If the *garment* consists of multiple layers, specimens of the *material* assembly shall be tested by applying the flame both to the surface of the outer material of the *garment* and to the innermost surface of the *garment*.

5.3.4 Mechanical properties of outer material

5.3.4.1 Tear resistance

For woven and laminated outer *material*, the test shall be carried out according to ISO 13937-2. If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.4.2 Tensile strength

For woven and laminated outer *material*, the test shall be carried out according to ISO 13934-1 (strip). If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.4.3 Burst strength

For knitted outer *material*, the test shall be carried out according to either ISO 13938-1 or ISO 13938-2. If the *garment* consists of several layers, only the outer *material* shall be tested.

5.3.5 Dimensional change due to laundering and/or dry cleaning

The test procedure shall be carried out in accordance with ISO 5077 after five cleaning cycles (a cleaning cycle is one wash and one dry cycle) according to manufacturer's instructions.

NOTE Manufacturer's instructions typically indicate one or several of the various methods and processes of ISO 6330, ISO 15797 or equivalent, as standardized processes for cleaning.

5.4 Tests of arc thermal protection requirements

5.4.1 Type tests

At least one of the two possible standard tests according to 4.4 shall be performed.

– IEC 61482-1-1 (method 1, both procedure A and procedure B).

  Testing according to IEC 61482-1-1 provides the $ELIM$, $ATPV$ or EBT.

– IEC 61482-1-2 (method 2, both *material* box test procedure and *garment* box test procedure).

  Testing according to IEC 61482-1-2 makes it possible to decide whether the requirements of Class 1 or Class 2 are fulfilled.

The arc exposure shall be applied to the outer surface of the test specimens.

If the *garment* or the *garment system* consists of layers intended for *arc thermal protection* (see Tables 1, 2 and 4), the material test shall be done on test specimens consisting of all layers.

If the *garment* or the *garment system* consists of multiple layers and there are intermediate layers not intended for *arc thermal protection* (see Table 3), the *material* test shall be done on test specimens consisting of all layers which are on top of the outermost intermediate layer that is not intended for *arc thermal protection*.

5.4.2 Alternative means to arc thermal protection test to fulfil conformity assessment of protective clothing having completed the production phase

There is no real alternative test to the *arc thermal protection* test (destructive test) after completing the production phase for checking the conformity to the associated requirement.

Nevertheless the *garment* manufacturer shall prove that he has followed the same documented assembly procedure with identical components (*materials* and accessories) as per the type tested *garment*. The *material* manufacturer shall prove that he has followed the same documented manufacturing process as per the type tested *material*.

5.5 Marking

5.5.1 Visual inspection

It shall be checked by visual inspection whether the requirements of 4.5 are fulfilled.

5.5.2 Durability of marking

The marking shall be rubbed for 15 s ± 1 s with a water-soaked lint-free cloth and then be rubbed for 15 s ± 1 s with a lint-free cloth soaked with isopropanol (CH_3-CH(OH)-CH_3).

NOTE It is not within the scope of this document to ensure that the relevant legislation and safety requirements for the use of this chemical are complied with in their entirety.

The test shall be considered as passed if the marking is still easily legible and the label has not curled or become detached.

5.6 Instructions for use

It shall be checked by visual inspection whether the requirements of 4.6 are fulfilled.

6 Conformity assessment of protective clothing having completed the production phase

For conducting the conformity assessment during the production phase, IEC 61318 shall be used in conjunction with this document.

Annex C provides the classification of defects and identifies the associated tests applicable for follow-up of production of *protective clothing* intended to comply with this document. A rationale for this classification is given in Annex D.

7 Modifications

Any modification of the *material* from which the *garment* is made, as well as any modification of the design, shall require the type tests to be repeated, in whole or in part (if the degree of modification so justifies), and shall require a change in *garment* marking and instructions for use if needed.

Annex A
(normative)

Marking and instructions for use

A.1 Marking

Each *garment* or *garment system* complying with this document shall have a marking label which shall contain at least the following items of marking:

– name, trade mark or other means of identification of the manufacturer or of its authorized representative;

– designation of the product type, commercial name or code;

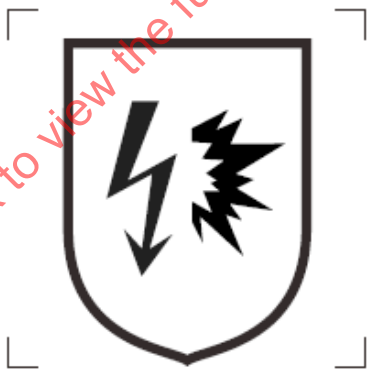
– size designation according to Clause 6 of ISO 13688:2013;

– care labelling in accordance with ISO 3758 and/or ISO 30023;

– symbol IEC 60417-6353:2016-02 – Protection against the thermal effect of the electric arc – and, adjacent to the symbol, the number of the relevant IEC standard (IEC 61482-2) and the *arc thermal protection* in the form of *arc rating* (*ELIM* and/or the lower value of either *ATPV* or *EBT*) and/or *arc protection class* (*APC* 1 or *APC* 2).

NOTE 1 The exact ratio of the height of the figure to the base is 1,43:1. For the purpose of convenience, this ratio can be between the values of 1,4:1 and 1,5:1.

NOTE 2 The text in the boxes below the symbol are examples.



IEC 61482-2
ELIM = yyy cal/cm^2
ATPV = xxx cal/cm^2

or

IEC 61482-2
APC = y

or

IEC 61482-2
ELIM = xxx cal/cm^2
APC = z

or

IEC 61482-2

undershirt ref. AAA: not determined
jacket ref. BBB: *ATPV* = xxx cal/cm^2 / APC = y
parka ref. CCC: *ELIM* = xxx cal/cm^2 / APC = y

Garment system: *ATPV* = xxx cal/cm^2 / APC = z

The marking of a *garment system* shall mention each item of the system, identified by a clear reference code and, if determined, the obtained *arc thermal protection*, as well as the *arc ratings* and/or *arc protection class* of the whole *garment system*.

NOTE 3 For the end user it may be helpful to have the pictograms also on the outside.

A.2 Instructions for use

Protective clothing shall be supplied to the customer with information written at least in the official language(s) of the country of destination. All information shall be unambiguous. It shall include at least the following:

– name and full address of the manufacturer and/or authorized representative;
– product designation;
– number of this document (IEC 61482-2) with the year of publication (four digits);
– pictograms, information and explanation about the type of arc test (*arc rating* or *arc protection class*);
– information on sizing;
– information to the user that
  - the environmental conditions and the risks at the working site shall be regarded;
  - deviations from the parameters in this document may result in more severe conditions;
  - *protective clothing* shall be worn in the closed state;
  - *protective clothing* according to this document is not intended to be used as electrical insulating *protective clothing* and does not provide protection against electrical shock;
  - *protective clothing* that becomes contaminated with grease, oil, or flammable liquids or combustible materials should not be used;
  - *protective clothing* should be cleaned when necessary;
  - *protective clothing* that is damaged to the extent that its protective qualities are impaired (e.g. holes in the garment, not functioning closures) should not be used;
– information to the user
  - about the protective level of all *garments* and of the *garment system*;
  - if the *garment* is made of different *materials* (e.g. for the front and back), by means of a drawing of the *garment* including dimensions and warning indication;
  - that for full body protection suitable additional protective equipment (helmet with protective face screen, protective gloves and footwear (boots)) shall be used;
  - that other *garments* worn together with *protective clothing* and dirty *protective clothing* can reduce the protection;
  - that damaged *garments* should be repaired or replaced. In the event of tearing, such damaged clothing should not be repaired; repairing is only allowed in accordance with the manufacturer's instructions;
  - that no *garments* like shirts, undergarments or underwear made of, for example, polyamide, polyester or acryl fibres which melt under arc exposures, should be used;
– care instructions in accordance with ISO 3758 and/or ISO 30023;
– repair instructions (e.g. warnings: repairs shall not impair the performance of the clothing; repair only with identical *material* and by suitably qualified companies; do not repair it yourself);
– storage instructions (e.g. store in dry and dust-free conditions; no storage under intensive light exposure).

Annex B
(normative)

Type tests

A list of type tests with reference to corresponding subclauses is given in Table B.1.

Table B.1 – List of type tests

Type of test	Subclauses	
	Requirements	Tests
Tests on *materials*		
Heat resistance **Volume resistance** **Limited flame spread** **Ageing**	4.3.1 4.3.2 4.3.3 4.2	5.3.1 5.3.2 5.3.3 5.2.4
Mechanical properties Tear resistance Tensile strength Burst strength Dimensional change	 4.3.4.1 4.3.4.2 4.3.4.3 4.3.5	 5.3.4.1 5.3.4.2 5.3.4.3 5.3.5
Arc thermal protection *Arc rating* (Procedure A) *Arc protection class* (Material box test)	4.4.1 4.4.2 4.4.3	5.4.1
Tests on *garments*		
Design *Garment* construction and workmanship Size designation and ergonomics Threads and closures	4.2	5.2.1 5.2.2 5.2.3 5.2.5
Limited flame spread (verification of the correct classification of the different layers)	4.3.3.2 4.3.3.3	5.2.1
Arc thermal protection *Arc rating* (Procedure B) *Arc protection class* (Garment box test)	4.4.1 4.4.2 4.4.3	5.4.1
Marking General requirements of ISO 13688 Presence and correctness of the specified marking Durability of the marking	4.5	5.5 5.5.1 5.5.1 5.5.2
Instructions for use	4.6	5.6

Annex C
(normative)

Classification of defects

Annex C was developed to classify the types of defect of *protective clothing* against the thermal hazards of an electric arc having completed the production phase (critical, major and minor) in a consistent manner (see IEC 61318). For each requirement identified in Table C.1, both the type of defect and the associated tests are specified.

The manufacturer shall test the materials and garments for certification and at a frequency to ascertain the protective performance for critical defects (see 5.4.2).

Table C.1 – Classification of defects and associated requirements and tests

Requirement		Type of defect			Test subclauses
		Critical	Major	Minor	
Requirements on *materials* (the unit of production is the required amount of *material*)					
4.3.1	**Heat resistance**	X			5.3.1
4.3.2	**Volume resistance**	X			5.3.2
4.3.3 4.3.3.1 4.3.3.2 4.3.3.3	**Limited flame spread of *material*** Classification Single-layer *material* Multi-layer *material*	 X [a] X [a] X [a]			 5.3.3 5.3.3 5.3.3
4.3.4.1	**Tear resistance of outer *material***		X		5.3.4.1
4.3.4.2	**Tensile strength of outer *material***		X		5.3.4.2
4.3.4.3	**Burst strength of outer *material***		X		5.3.4.3
4.3.5	**Dimensional change**			X	5.3.5
4.4	**Arc thermal protection** *Arc rating* (Procedure A) *Arc protection class* (Material box test)	X			5.4.1
Requirements on *garments* (the unit of production is a *garment*)					
4.2	**Design** *Garment* construction and workmanship Size designation and ergonomics Ageing Threads and closures	 X X	 X	 X	 5.2.2 5.2.3 5.2.4 5.2.5
4.4	**Arc thermal protection** *Arc rating* (Procedure B) *Arc protection class* (Garment box test)	X			5.4.1
4.5	**Marking** General requirements of ISO 13688 Presence and correctness of the specified marking Durability of the marking		 X X	 X	 5.5.1 5.5.1 5.5.2
4.6	**Instructions for use**		X		5.6

As a minimum unit, a roll of *material* should be considered.

[a] Limited flame spread shall be assessed and documented by the *material* manufacturer for the lot size. The lot size is, as a minimum, the amount of material delivered to the *garment* manufacturer.

Annex D
(informative)

Rationale for the classification of defects

Annex D provides the rationale for the classification of defects specified in Annex C. For brand new *protective clothing*, Table D.1 presents the justification for the type of defect associated with a lack of compliance with each of the requirements included in the standard.

This analysis takes into consideration that the products are used by skilled persons and in accordance with safe methods of work.

Table D.1 – Justification for the type of defect

Requirement	Justification for the associated defect specified in Annex C
Material	
Critical defects	
Heat resistance Volume resistance Limited flame spread of *material* *Arc thermal protection*	These defects are the most important aspects of *arc thermal protection*; they cannot be detected by the worker; they need to be assessed and documented by the *material* manufacturer.
Major defects	
Tear resistance	This defect can be directly detected by the worker who will not use the *protective clothing*.
Tensile strength	This defect can be directly detected by the worker who will not use the *protective clothing*.
Burst strength	This defect can be directly detected by the worker who will not use the *protective clothing*.
Minor defects	
Dimensional change	It is not likely that a shrinkage will result in a failure of the *protective clothing*.
Garments	
Critical defects	
Design of *garments*: *Garment* construction and workmanship Ageing	Wrong construction with insufficient *material* in the *garment* may be a hazard for the user. Insufficient performance of the *garment* after a certain number of care cycles may be a hazard for the user.
Arc thermal protection	Wrong construction with insufficient *material* in the *garment* may be a hazard for the user.
Major defects	
Design of *garments*: Thread and closures	With defective closures, the worker will not use the *protective clothing*.
Marking: Presence of marking Durability of the marking	Without marking, the worker will not use the *protective clothing*. With illegible marking, the worker will not use the *protective clothing*.
Instructions for use	Without instructions, the worker will not use the *protective clothing*.

Requirement	Justification for the associated defect specified in Annex C
Minor defects	
Design of *garments*: Size designation and ergonomics	It is not likely that this will result in a failure of the *protective clothing*.
Marking: General requirements of ISO 13688	General marking requirements have a minor influence on the *arc thermal protection* and are not likely to result in a failure.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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TRAVAUX SOUS TENSION – VÊTEMENTS DE PROTECTION CONTRE LES DANGERS THERMIQUES D'UN ARC ÉLECTRIQUE –

Partie 2: Exigences

AVANT-PROPOS

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La Norme internationale IEC 61482-2 a été établie par le comité d'études 78 de l'IEC: Travaux sous tension.

Cette deuxième édition annule et remplace la première édition parue en 2009. La présente édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) nouvelle définition des valeurs d'*ELIM*, d'*ATPV* et d'*EBT*, telles qu'utilisées conformément à l'IEC 61482-1-1:–;
b) nouvelles exigences relatives à la stabilité thermique des couches intermédiaires;

c) exigence supplémentaire du matériau concernant la résistance électrique;

d) nouvelle procédure d'essai pour la résistance thermique des fils de couture;

e) nouveau symbole de marquage

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
78/1205/FDIS	78/1228/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Les termes définis à l'Article 3 sont imprimés en *caractères italiques* dans la présente norme.

Une liste de toutes les parties de la série IEC 61482, publiées sous le titre général *Travaux sous tension – Vêtements de protection contre les dangers thermiques d'un arc électrique*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Le présent document a été rédigé en conformité avec les exigences de l'IEC 61477.

Les produits conçus et fabriqués conformément au présent document contribuent à la sécurité des utilisateurs, pourvu qu'ils soient utilisés par des personnes qualifiées, conformément à des méthodes de travail sûres et aux instructions d'emploi.

Le produit couvert par le présent document peut avoir un impact sur l'environnement pendant certaines étapes de son cycle de vie ou tout au long de celui-ci. La gravité de ces impacts peut s'échelonner de faible à forte, ils peuvent être de courte ou de longue durée, et se produire à un niveau local, régional ou global.

Le présent document ne contient pas d'exigences ni de dispositions d'essai s'adressant au fabricant, ou de recommandations aux utilisateurs du produit ayant pour but d'améliorer l'environnement. Cependant, toutes les parties qui interviennent dans sa conception, sa fabrication, son emballage, sa distribution, son utilisation, son entretien, sa réparation, sa réutilisation, sa récupération et sa mise au rebut sont invitées à prendre en compte les éléments environnementaux.

TRAVAUX SOUS TENSION – VÊTEMENTS DE PROTECTION CONTRE LES DANGERS THERMIQUES D'UN ARC ÉLECTRIQUE –

Partie 2: Exigences

1 Domaine d'application

La présente partie de l'IEC 61482 est applicable aux *vêtements de protection* utilisés pour réaliser des travaux lorsqu'il y a un risque d'exposition à un *danger d'arc électrique*.

Le présent document spécifie les exigences et les méthodes d'essai applicables aux *matériaux et aux articles d'habillement* utilisés pour les *vêtements de protection* des travailleurs du domaine électrique contre les dangers thermiques d'un *arc électrique*.

Les dangers de chocs électriques ne sont pas couverts par le présent document, qui est applicable en combinaison avec les normes couvrant ce type de dangers.

Le présent document ne couvre que les effets thermiques d'un *arc électrique,* et ne couvre pas les effets comme le bruit, les émissions lumineuses, l'augmentation de la pression, l'huile chaude, le choc électrique, les conséquences d'un choc physique ou mental ou des effets toxiques lors d'un arc électrique.

Le présent document ne couvre pas la protection des yeux, du visage, de la tête, des mains et des pieds contre le *danger d'arc électrique*.

NOTE Les exigences et les essais applicables aux dangers d'arc électrique concernant ces parties du corps sont en cours d'élaboration.

Le présent document ne couvre pas les *vêtements de protection* portés pour réaliser des travaux utilisant intentionnellement un *arc électrique*, par exemple le soudage à l'arc, l'usage d'une torche à plasma.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60417, *Symboles graphiques utilisables sur le matériel* (disponible à l'adresse http://www.graphical-symbols.info/equipment)

IEC 61318, *Travaux sous tension – Evaluation de la conformité applicable à l'outillage, au matériel et aux dispositifs*

IEC 61340-2-3:2016, *Électrostatique – Partie 2-3: Méthodes d'essais pour la détermination de la résistance et de la résistivité des matériaux solides destinés à éviter les charges électrostatiques*

IEC 61477, *Travaux sous tension – Exigences minimales pour l'utilisation des outils, dispositifs et équipements*

IEC 61482-1-1:–[1], *Travaux sous tension – Vêtements de protection contre les dangers thermiques d'un arc électrique – Partie 1-1: Méthodes d'essai – Méthode 1: Détermination de la valeur assignée d'arc (ELIM, ATPV et/ou EBT) des matériaux pour vêtements et des vêtements de protection utilisant un arc ouvert*

IEC 61482-1-2, *Travaux sous tension – Vêtements de protection contre les dangers thermiques d'un arc électrique – Partie 1-2: Méthodes d'essai – Méthode 2: Détermination de la classe de protection contre l'arc de matériaux et de vêtements au moyen d'un arc dirigé et contraint (enceinte d'essai)*

ISO 3146, *Plastiques – Détermination du comportement à la fusion (température de fusion ou plage de températures de fusion) des polymères semi-cristallins par méthodes du tube capillaire et du microscope polarisant*

ISO 3758, *Textiles – Code d'étiquetage d'entretien au moyen de symboles*

ISO 5077, *Textiles – Détermination des variations dimensionnelles au lavage et au séchage domestiques*

ISO 13688:2013, *Vêtements de protection – Exigences générales*

ISO 13934-1, *Textiles – Propriétés des étoffes en traction – Partie 1: Détermination de la force maximale et de l'allongement à la force maximale par la méthode sur bande*

ISO 13937-2, *Textiles – Propriétés de déchirement des étoffes – Partie 2: Détermination de la force de déchirure des éprouvettes pantalons (Méthode de la déchirure unique)*

ISO 13938-1, *Textiles – Propriétés de résistance à l'éclatement des étoffes – Partie 1: Méthode hydraulique pour la détermination de la résistance et de la déformation à l'éclatement*

ISO 13938-2, *Textiles – Propriétés de résistance à l'éclatement des étoffes – Partie 2: Méthode pneumatique pour la détermination de la résistance et de la déformation à l'éclatement*

ISO 15025, *Vêtements de protection – Protection contre les flammes – Méthode pour la propagation de flamme limitée*

ISO 17493:2016, *Vêtements et équipement de protection contre la chaleur – Méthode d'essai de la résistance à la chaleur de convection au moyen d'un four à circulation d'air chaud*

ISO 30023, *Textiles – Symboles de qualification pour l'étiquetage des vêtements de travail destinés à être lavés de manière industrielle*

3 Termes, définitions, symboles et unités

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 61318 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

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1 En cours d'élaboration. Stade au moment de la publication: IEC CDV 61482-1-1:2017.

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1.1
classe de protection contre l'arc
APC
<essai d'*arc électrique*> catégorie de *protection thermique contre l'arc* d'un matériau et/ou d'un produit soumis aux essais conformément à l'essai dans l'enceinte d'essai (APC 1 ou APC 2)

Note 1 à l'article: La *classe de protection contre l'arc* est caractérisée par le niveau de l'énergie d'essai de l'exposition à l'arc (*énergie d'arc* et énergie incidente).

Note 2 à l'article: Le *matériau* et/ou les produits soumis à l'essai présentent une *protection thermique contre l'arc* au moins jusqu'au *niveau d'énergie de la classe* mais en règle générale, la limite d'énergie d'exposition réelle de protection offerte par le *matériau* et/ou le produit est plus élevée.

Note 3 à l'article: L'abréviation «APC» est dérivée du terme anglais développé correspondant «arc protection class».

3.1.2
valeur assignée d'arc
<*essai d'arc électrique*> valeur numérique attribuée à un produit, qui décrit sa performance de protection à l'exposition à un arc électrique

Note 1 à l'article: La *valeur assignée d'arc* peut être la valeur de performance thermique à l'arc ($ATPV$), la valeur d'énergie de seuil à l'éventration (EBT) ou la limite d'énergie incidente ($ELIM$).

Note 2 à l'article: La *valeur assignée d'arc* est exprimée en kJ/m^2 (cal/cm^2).

3.1.3
protection thermique contre l'arc
<*essai d'arc électrique*> degré de protection thermique assuré contre les *arcs électriques* dans des conditions d'essai d'arc spécifiques indiquées soit par la *valeur assignée d'arc* soit par la *classe de protection contre l'arc*

Note 1 à l'article: Pour les matériaux, la protection thermique contre l'arc est obtenue à partir du mesurage de l'énergie transmise et par l'évaluation d'autres paramètres thermiques (temps de combustion, formation de trous, fusion).

Note 2 à l'article: Pour les *articles d'habillement*, la *protection thermique contre l'arc* est obtenue par l'évaluation des paramètres thermiques (temps de combustion, formation de trous, fusion) du (des) *matériau*(x) dont est fait l'*article d'habillement* et du fonctionnement des fermetures et des accessoires.

3.1.4
valeur de performance thermique à l'arc
ATPV
<*essai d'arc électrique*> valeur numérique d'énergie incidente attribuée à un produit qui décrit ses propriétés thermiques d'atténuation (réduction) d'un flux de chaleur généré par un *arc électrique*

Note 1 à l'article: L'$ATPV$ d'un *matériau* ou d'un assemblage de matériaux est calculé en utilisant une analyse de régression logistique appliquée aux points de données obtenus par les essais d'un ensemble d'éprouvettes d'essai. L'$ATPV$ est la valeur d'énergie incidente à laquelle le transfert de chaleur à travers l'éprouvette d'essai est suffisant pour atteindre les critères de Stoll avec une probabilité de 50 %.

Note 2 à l'article: L'$ATPV$ attribuée à un *article d'habillement* ou à un *assemblage d'articles d'habillement* est soit égale, soit inférieure à l'$ATPV$ *du matériau* ou de l'assemblage de matériaux dont il est fait, selon que les éprouvettes d'essai remplissent ou non aussi des critères supplémentaires de conception visuels et d'évaluation des performances.

Note 3 à l'article: L'abréviation «$ATPV$» est dérivée du terme anglais développé correspondant «arc thermal performance value».

3.1.5
énergie de seuil à l'éventration
EBT
<essai d'*arc électrique*> valeur numérique d'énergie incidente attribuée à un produit qui décrit ses propriétés d'éventration lorsqu'il est exposé à un flux de chaleur généré par un *arc électrique*

Note 1 à l'article: L'*EBT* d'un *matériau* ou d'un assemblage de matériaux est calculée en utilisant une analyse de régression logistique appliquée aux points de données obtenus par les essais d'un ensemble d'éprouvettes d'essai. L'*EBT* est la valeur d'énergie incidente à laquelle l'éventration se produit avec une probabilité de 50 %.

Note 2 à l'article: L'*EBT* attribuée à un *article d'habillement* ou à un *assemblage d'articles d'habillement* est soit égale, soit inférieure à l'*EBT du matériau* ou de l'assemblage de matériaux, dont il est fait, selon que les éprouvettes d'essai remplissent ou non aussi des critères supplémentaires de conception visuels et d'évaluation des performances.

Note 3 à l'article: L'abréviation «*EBT*» est dérivée du terme anglais développé correspondant «breakopen threshold energy».

3.1.6
arc électrique
conduction gazeuse autonome dans laquelle la plupart des porteurs de charge sont des électrons produits par émission électronique primaire

Note 1 à l'article: Au cours des travaux sous tension, l'*arc électrique* est généré par une ionisation gazeuse qui résulte d'une connexion électrique ou d'un claquage accidentel(le) entre des parties sous tension ou entre une partie sous tension et un circuit de terre d'une installation électrique ou un dispositif électrique. Au cours des essais, l'*arc électrique* est initié par la fusion d'un fil fusible.

[SOURCE: IEC 60050-121:1998, 121-13-12, modifiée – La note 1 à l'article a été ajoutée pour faire spécifiquement référence aux travaux sous tension et aux essais d'arc.]

3.1.7
danger d'arc électrique
dommage potentiel causé par l'évacuation de l'énergie d'un *arc électrique* généralement provoqué par un court-circuit ou une défaillance de l'équipement lors de travaux électrotechniques

Note 1 à l'article: Un *danger d'arc électrique* existe lorsque des conducteurs ou des parties électriques sous tension sont exposé(e)s et qu'ils(elles) se trouvent à l'intérieur d'un élément de l'équipement, même si celui-ci est protégé ou sous enveloppe, si un travailleur interagit avec l'équipement d'une façon pouvant provoquer un *arc électrique*. Dans des conditions normales de fonctionnement, un équipement sous tension sous enveloppe qui a été correctement conçu, installé et entretenu n'est pas susceptible de présenter un *danger d'arc électrique*.

Note 2 à l'article: Les documents tels que la norme NFPA 70E, la norme IEEE 1584, le Guide ISSA, la publication DGUV-I 203-77 aident à évaluer les dangers d'un point de vue pratique.

Note 3 à l'article: Les dangers peuvent comprendre les effets thermiques, le bruit, les effets d'onde de pression, les effets des parties projetées, le métal fondu, les effets optiques et autres. Différents EPI (équipements de protection individuelle) peuvent être exigés pour assurer une protection contre les différents effets. Il est important que l'appréciation du risque prenne en compte tous les effets potentiels.

3.1.8
article d'habillement
chacun des éléments du vêtement, pouvant se composer d'une seule ou de plusieurs couches de matériau

3.1.9
système d'articles d'habillement
assemblage *d'articles d'habillement* auquel sont attribuées des *valeurs assignées d'arc* ou une *classe de protection contre l'arc* spécifiques après un essai d'arc

3.1.10
autres matières
éléments autre que l'étoffe, pouvant faire partie d'un *article d'habillement*

3.1.11
limite d'énergie incidente
ELIM
<<*essai d'arc électrique*>> valeur numérique d'énergie incidente attribuée à un produit, en dessous de laquelle il n'existe pas de point de données pour lequel la quantité de chaleur transmise à travers le produit atteint les critères de Stoll ou le produit présente une éventration

Note 1 à l'article: L'*ELIM* d'un *matériau* ou d'un assemblage de matériaux est calculée à partir des points de données obtenus par les essais d'un ensemble d'éprouvettes d'essai, qui sont aussi utilisés pour la détermination de l'*ATPV* et/ou de l'*EBT*.

Note 2 à l'article: L'*ELIM* attribuée à un *article d'habillement* ou à un *assemblage d'articles d'habillement* est soit égale, soit inférieure à l'*ELIM du matériau* ou de l'assemblage de matériaux dont il est fait, selon que les éprouvettes d'essai remplissent ou non aussi des critères supplémentaires de conception visuels et d'évaluation des performances.

Note 3 à l'article: L'abréviation «*ELIM*» est dérivée du terme anglais développé correspondant «Incident energy limit».

3.1.12
matériau
substances excluant les *autres matières* dont est constitué un article d'habillement

[SOURCE ISO 11612:2015, 3.13, modifié – Dans la définition, le terme "accessoires" est remplacé par "autres matières".]

3.1.13
arc électrique à l'air libre
<essai d'*arc électrique*> *arc électrique* entre deux électrodes opposées verticalement destinées à assurer une répartition uniforme de l'énergie émise autour de la ligne centrale formée par les électrodes, l'énergie émise n'étant pas dirigée par une contrainte physique (par exemple enveloppe, mur)

3.1.14
vêtement de protection
vêtement recouvrant ou remplaçant le vêtement personnel et conçu pour protéger contre un ou plusieurs dangers

[SOURCE: ISO TR 11610:2004, 3.178]

3.2 Symboles et unités

APC	arc protection class (classe de protection contre l'arc)	1 ou 2
ATPV	arc thermal performance value (valeur de performance thermique à l'arc)	kJ/m^2 ou cal/cm^2
EBT	breakopen threshold energy (énergie de seuil à l'éventration)	kJ/m^2 ou cal/cm^2
ELIM	incident energy limit (limite d'énergie incidente)	kJ/m^2 ou cal/cm^2

NOTE 1 kJ/m^2 = 1 kWs/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 Exigences

4.1 Généralités

Les exigences générales applicables aux *vêtements de protection* contre les dangers thermiques d'un arc électrique qui ne sont pas spécifiquement couverts par le présent document doivent être conformes à l'ISO 13688.

4.2 Exigences de conception des vêtements de protection

Les *articles d'habillement* qui protègent le haut du corps doivent avoir des manches suffisamment longues pour couvrir le bras jusqu'aux poignets et doivent couvrir le haut du corps jusqu'au cou. Les *articles d'habillement* qui protègent le bas du corps doivent couvrir le corps de la taille aux chevilles.

Les fermetures de l'*article d'habillement* doivent être conçues de telle façon que la fonction d'ouverture soit toujours opérationnelle après exposition à un arc lorsqu'elles sont soumises à l'essai selon 5.2.5.

Les accessoires (par exemple les étiquettes, les badges, les matériaux rétro-réfléchissants) et les fermetures utilisés dans la confection de l'*article d'habillement* ne doivent pas aggraver les blessures de la personne qui le porte en cas d'*arc électrique* et d'exposition thermique associée lorsque le vêtement est soumis à l'essai d'article d'habillement décrit en 5.4. La rupture de la fermeture ne doit pas se produire.

Le fil de couture utilisé dans la confection des *articles d'habillement* doit être constitué de fibres résistant naturellement à la flamme et ne doit pas fondre lorsqu'il est soumis à l'essai selon 5.2.5. Il n'est pas nécessaire que les fils dans les coutures qui ne jouent pas de rôle de protection, par exemple les ourlets, les coutures de poche, etc., soient résistants à la flamme.

Aucune partie métallique extérieure non couverte ne doit être permise dans le vêtement. Les *autres matières* insérées dans le *matériau* extérieur de l'*article d'habillement* ne doivent pas être exposées à la surface la plus interne de l'*article d'habillement*.

Toutes les parties apparentes d'un *article d'habillement* doivent être constituées de *matériaux assurant une protection thermique contre l'arc*. Lorsque des *matériaux* différents sont utilisés pour le devant et le dos de l'*article d'habillement*, l'information exacte sur la localisation de la surface de moindre protection doit être donnée dans les instructions d'emploi (par exemple au moyen d'un dessin de l'*article d'habillement* accompagné des dimensions et d'une indication de mise en garde).

NOTE 1 L'utilisateur peut réaliser une appréciation du risque afin de déterminer le niveau de protection nécessaire. Les documents tels que la norme NFPA 70E, la norme IEEE 1584, le Guide ISSA, la publication DGUV-I 203-77 aident à évaluer les dangers d'un point de vue pratique.

Pour les *articles d'habillement* couvrant le torse et les bras, le devant ainsi que les manches complètes, tout autour des bras et sur leur longueur totale, doivent satisfaire à la même *protection thermique contre l'arc*.

Pour les *articles d'habillement* couvrant les jambes, le devant sur la longueur totale doit satisfaire à la même *protection thermique contre l'arc.*

Pour les combinaisons, les exigences relatives aux *articles d'habillement* couvrant le torse, les bras et à ceux couvrant les jambes doivent être satisfaites.

Lorsque la protection est assurée par un ensemble externe en deux pièces, il doit être vérifié, lorsque la taille est appropriée, que le chevauchement entre la veste et le pantalon est toujours maintenu lorsque le porteur tend d'abord les bras au-dessus de la tête puis se penche en avant jusqu'à toucher le sol du bout des doigts pendant les essais selon 5.2.1.

Lorsqu'un fabricant revendique qu'un *système d'articles d'habillement* constitue un *vêtement de protection* thermique contre l'arc, ce *système d'articles d'habillement* doit être soumis à l'essai et doit satisfaire aux exigences du présent document.

NOTE 2 Lorsqu'un utilisateur porte comme *vêtement de protection* thermique contre l'arc des *articles d'habillement* provenant de différents fabricants, c'est à lui qu'incombe la responsabilité d'évaluer si l'assemblage satisfait aux exigences du présent document.

4.3 Exigences générales du matériau

4.3.1 Résistance à la chaleur

Les *matériaux* ne doivent pas s'enflammer, fondre ou rétrécir de plus de 5 % lorsqu'ils sont soumis à l'essai selon 5.3.1.

4.3.2 Résistance électrique

Les *matériaux* de l'*article d'habillement* utilisant des fibres conductrices, à l'exception des *articles d'habillement* satisfaisant à l'IEC 60895, doivent présenter une résistance électrique d'au moins 10^5 Ω lorsqu'ils sont soumis à l'essai selon 5.3.2.

4.3.3 Propagation de flamme limitée du matériau

4.3.3.1 Classification de la propagation de flamme limitée

Tous les *matériaux* doivent atteindre un indice de propagation de flamme limitée spécifié, lorsqu'ils sont soumis à l'essai selon 5.3.3 et doivent être classés selon les Tableaux 1 à 4 suivants.

4.3.3.2 Matériau monocouche

Lorsque l'*article d'habillement* est constitué d'un *matériau* monocouche, ce *matériau* doit satisfaire aux exigences données dans le Tableau 1.

Tableau 1 – Matériau monocouche

Propriété	Exigence
Propagation de la flamme	Pour aucune éprouvette, le front inférieur de la flamme ne doit atteindre le bord supérieur ou le bord vertical de l'éprouvette.
Débris enflammés	Aucune éprouvette ne doit produire de débris enflammés ou fondus.
Formation de trous	Aucune éprouvette ne doit donner lieu à la formation de trous de 5 mm ou plus quelle que soit la direction.
Incandescence résiduelle	La durée d'incandescence résiduelle doit être ≤ 2 s. Une incandescence persistant à l'intérieur de la zone carbonisée est définie dans l'ISO 15025 comme une incandescence résiduelle sans combustion et, pour les besoins de 4.3.3.2, ne doit pas être considérée comme une incandescence résiduelle.
Flamme résiduelle	La durée de la flamme résiduelle doit être ≤ 2 s.

4.3.3.3 Matériau multicouche

Lorsque l'*article d'habillement* est constitué de plusieurs couches, tous les *matériaux* de la couche extérieure et de la couche la plus interne doivent satisfaire aux exigences données dans le Tableau 2.