

INTERNATIONAL STANDARD



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



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

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

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INTERNATIONAL STANDARD



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**LIVE WORKING –
PROTECTIVE CLOTHING AGAINST
THE THERMAL HAZARDS OF AN ELECTRIC ARC –****Part 2: Requirements****FOREWORD**

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

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

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

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

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

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

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

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

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

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

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

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- withdrawn,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

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INTRODUCTION

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

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

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

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

Part 2: Requirements

1 Scope

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

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

- ~~— relevant general properties of the textiles, tested with selected textile test methods, and~~
- ~~— are 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/m² (cal/cm²).

3.1.3

arc thermal protection

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

Note 1 to entry: For *materials*, the *arc thermal ~~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 DGVV-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 breakdown

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

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

NOTE $1 \text{ kJ/m}^2 = 1 \text{ kW} \cdot \text{s/m}^2 = 0,1 \text{ J/cm}^2 = 0,023885 \text{ cal/cm}^2$

$1 \text{ cal/cm}^2 = 41,840 \text{ kJ/m}^2 = 41,840 \text{ kW} \cdot \text{s/m}^2$

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 $10^5 \Omega$.

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~~ 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 <i>arc thermal protection</i> , 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 <i>arc thermal protection</i> .	

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/m² or at least 10 N for weight ~~within 150 g/m² and of 220 g/m² 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/m² or at least 250 N for weight ~~within 150 g/m² and of 220 g/m² 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 cm² test area, or of at least 200 kPa while using a 7,3 cm² test area when tested according to ~~ISO 13938-1~~ 5.3.4.3.

4.3.5 Dimensional change of material due to ~~laundrying 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/m² (4 cal/cm²). 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/m² (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/m² (4 cal/cm²) 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/m² (3,2 cal/cm²) and where the lower value of *ATPV* and *EBT* is at least 167 kJ/m² (4 cal/cm²). In case only either *ATPV* or *EBT* can be determined, this value shall be at least 167 kJ/m² (4 cal/cm²).

Due to the limitations of test apparatus at very high energy arcs, no *arc rating* above 4 186 kJ/m² (100 cal/cm²) 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 DGVV-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 *garments* 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 $20\text{ °C} \pm 2\text{ °C}$ and relative humidity $65\% \pm 5\%$ 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 ($60\text{ °C} \pm 3\text{ °C}$) 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 $15\text{ s} \pm 1\text{ s}$ with a water-soaked lint-free cloth and then be rubbed for $15\text{ s} \pm 1\text{ s}$ with a lint-free cloth soaked with isopropanol ($\text{CH}_3\text{-CH(OH)-CH}_3$).

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

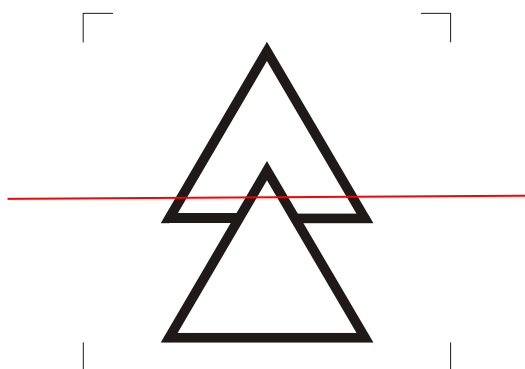
A.1 Marking

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 $E_{BT50} = xxx \text{ cal/cm}^2$
or
Class 1 or Class 2~~

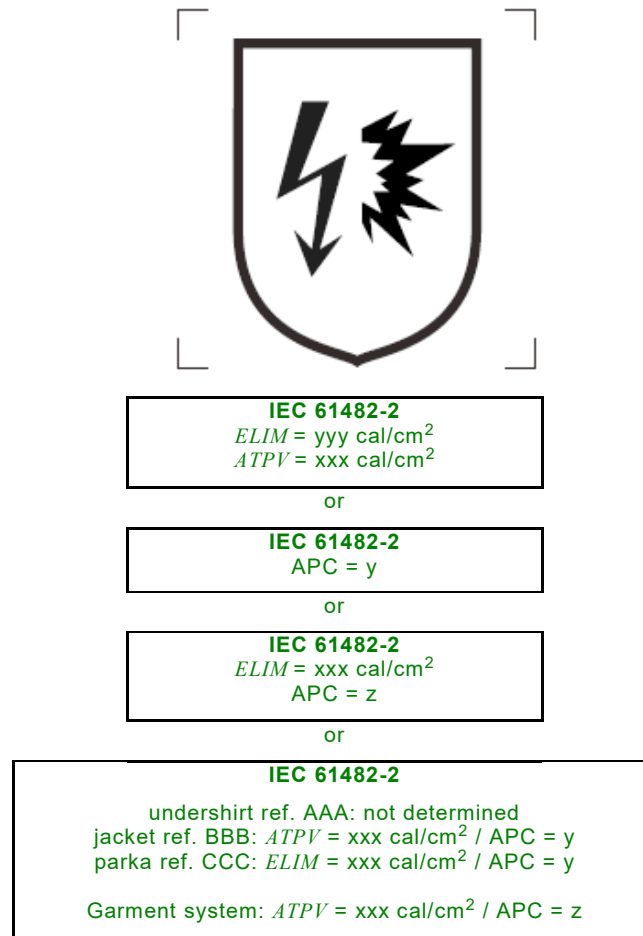
~~or~~

~~**IEC 61482-2**
ATPV or $E_{BT50} = xxx \text{ cal/cm}^2$
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.



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
<i>Tests on materials</i>		
Heat resistance	4.3.1	5.3.1
Volume resistance	4.3.2	5.3.2
Limited flame spread ~~(classification of the materials)~~	4.3.3	5.3.3
Ageing ~~(of the garment)~~	4.2	5.2.4
Mechanical properties		
Tear resistance	4.3.4.1	5.3.4.1
Tensile strength	4.3.4.2	5.3.4.2
Burst strength	4.3.4.3	5.3.4.3
Dimensional change	4.3.5	5.3.5
Arc thermal ~~resistance~~ protection ~~(ATPV test method A or Material box test)~~ <i>Arc rating</i> (Procedure A) <i>Arc protection class</i> (Material box test)	4.4.1 4.4.2 4.4.3	5.4.1
<i>Tests on garments</i>		
Design	4.2	5.2.1
<i>Garment</i> construction and workmanship		5.2.2
Size designation and ergonomics		5.2.3
Threads, ~~accessories~~ , and closures		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
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