IEC 60895

Edition 3.0 2020-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Live working – Conductive clothing

Travaux sous tension – Vêtements conducteurs

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

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LIVE WORKING – CONDUCTIVE CLOTHING

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 60895 has been prepared by IEC technical committee 78: Live working.

This third edition cancels and replaces the second edition, published in 2002. This edition constitutes a technical revision.

This 3edition includes the following significant technical changes with respect to the previous edition:

a) increase of the use up to 1 000 kV AC and ±800 kV DC;
b) introduction of two classes of conductive clothing with different electrical requirements;
c) revision of the electrical requirements of conductive clothing;
d) definition of specific resistance values for each component part of the conductive clothing;
e) introduction of conductive helmet and conductive scarf as *component parts* of conductive clothing;
f) introduction of mechanical requirements and new tests for fabrics;
g) update of the cleaning test procedures;

h) revision of the efficiency test of the conductive clothing to improve the feasibility and repeatability;

i) preparation of the elements of classification of defects, and general application of IEC 61318:2007;

j) the normative Annex B for the classification of tests has been replaced by normative Annex C for the general type tests procedure, the normative Annex D for the classification of defects and the informative Annex E providing the justification for the classification of defects;

k) the normative Annex C on sampling procedure has been deleted (not applicable according to IEC 61318:2007);

l) modification of the recommended frequency of the periodic tests.

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

FDIS	Report on voting
78/1309/FDIS	78/1312/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 publication 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.

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document provides specifications for protective *conductive clothing* currently being used without incident in live work by qualified electrical workers throughout the world. The adequacy of this clothing is established by its *screening efficiency* and the electrical resistance of material and *component parts* of the *conductive clothing*. Based on resistance measurements carried out by manufacturers and utilities of used clothing being successfully worn in the field, differences of up to 1 000 fold have been reported.

The whole set-up and preparation work in very high voltage is made to limit the power of electric arcs during work activities.

When, in the preparation phase of the work, the risk assessment leads to a high probability that there may be electric arcs, due to the short distances or unsuitable equipment insulation, the work is not done.

This approach is dictated by the fact that the electric arcs produced by high-voltage installations have very significant thermal and electrical effects, which are hardly attenuated by protective clothing worn by operators.

If protection against electric arc value is required by agreements between customer and manufacturer, it is possible to perform tests on the fabric and/or on the *garment* complete with accessories using the reference standards already published on this topic by IEC TC 78.

This document has been prepared according to the requirements of IEC 61477, where applicable.

The bibliography provides a list of papers of international level that were used during the development of this edition of IEC 60895.

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 – CONDUCTIVE CLOTHING

1 Scope

This document is applicable to *conductive clothing*, worn during live working (especially bare-hand working) on AC and DC electrical installations, to provide electrical continuity between all parts of the clothing and a reduction of electric field inside the clothing.

This document is applicable to *conductive clothing* assembled from a conductive *garment* (jackets and trousers or coveralls forming a one-piece *garment*) and from conductive *component parts* (gloves, hoods or helmets, shoes or boots, overshoe socks and socks) in electrical systems with nominal voltage up to 1 000 kV AC and up to ±800 kV DC.

This document does not indicate values of protection from the effects of the electric arc, because any value indicated would not guarantee the necessary protection from the effects of electric arcs, or the operator would need to wear very heavy and rigid conductive clothing, which would not allow the execution of the work in safety.

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

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 60212:2010, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

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

ISO 3175 (all parts), *Textiles – Professional care, drycleaning and wetcleaning of fabrics and garments*

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

ISO 12947-1, *Textiles – Determination of the abrasion resistance of fabrics by the Martindale method – Part 1: Martindale abrasion testing apparatus*

ISO 12947-2, *Textiles – Determination of the abrasion resistance of fabrics by the Martindale method – Part 2: Determination of specimen breakdown*

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

3 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
component part
additional element of the complete *conductive clothing* such as glove, sock, scarf, head cover, face screen, and footwear worn in addition to the main *garment* and bonded to it

3.2
conductive clothing
clothing made of natural or synthetic material(s) with integral interwoven conductive fibres or layers used to provide electrical continuity between all parts of the clothing and a reduction of the electric field inside the clothing

Note 1 to entry: The term *conductive clothing* includes conductive jacket, trousers, coverall (one-piece clothing), gloves, hood, overshoe socks and socks.

Note 2 to entry: *Conductive footwear* and conductive helmet are *component parts* used in conjunction with the *conductive clothing*.

[SOURCE: IEC 60743:2013, 8.1.8]

3.3
conductive element
metallic thread or non-metallic conductive substance used to make conductive material

3.4
conductive face screen
protective device made of conductive solid or meshed material affording protection to the face of the worker, or portion thereof, from an electric field

SEE: Figure H.1

[SOURCE: IEC 60743:2013, 8.1.9]

3.5
conductive footwear
protective footwear made with a conductive sole

SEE: Figure H.1

Note 1 to entry: The *conductive footwear* may have a conductive strap for connecting the *conductive clothing*.

Note 2 to entry: *Conductive footwear* may also provide a certain mechanical protection.

3.6
conductive glove
component part for the protection of hands

SEE: Figure H.1

3.7
conductive head cover
part of clothing, either as a separate item or integrated into a complete *garment*, that covers the head

SEE: Figure H.1

Note 1 to entry: For example, a *conductive head cover* can be a conductive hood or a conductive helmet.

3.8
conductive material
material composed of metallic threads or non-metallic conductive substances and natural or synthetic threads closely woven, knitted, or layered

3.9
conductive overshoe sock
conductive sock
sock made of *conductive material*, worn over shoe or boot

SEE: Figure H.1

3.10
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

SEE: Figure H.1

[SOURCE: IEC 60050-826:2004, 826-13-19]

3.11
equipotential bonding lead
flexible conductive connection used by the worker to connect the *conductive clothing* to another conductive part to create *equipotential bonding*

Note 1 to entry: An *equipotential bonding lead* is not an earthing device.

[SOURCE: IEC 60743:2013, 8.1.6, modified – The definition has been modified to fit the specific application.]

3.12
garment
main body of the clothing, either one piece or consisting of jacket and trousers

SEE: Figure H.1

3.13
screening efficiency
base 10 logarithm of the ratio of the total current injected into the *conductive clothing* and the body to the current flowing only in the body

3.14
shielding efficiency
base 10 logarithm of the ratio of a voltage without the *conductive material* to the voltage measured at the spot with *conductive material*

3.15
test piece
part of fabric or other part of *conductive material* used for the tests

4 Requirements

4.1 General

The following requirements have been prepared in order that the products covered by this document are designed and manufactured to contribute to the safety of the users, provided they are used by persons skilled for live working, in accordance with safety method of work and the instructions for use.

4.2 Requirements for conductive clothing

4.2.1 Design

The *conductive clothing* shall constitute an electrically continuous assembly for the worker.

The *conductive clothing* can be made of a single *conductive material* layer, or it can be made of a multilayer. In case of a multilayer, the outer layer material of the *conductive clothing* may be conductive or non-conductive, but at least one layer shall be conductive.

If press studs, zip fasteners, hooks and eyes or any other method of fastening are used in the assembly of the complete *conductive clothing*, the electrical conductivity of the clothing should not be impaired.

The bonding lead shall be capable of withstanding the anticipated electrical and mechanical stresses. The design of the *equipotential bonding lead* should be such that it does not interfere with the emergency procedures, for example, in case of a fall.

If the *garment* is made up of more than one piece (for example, separate jacket or trousers), the method of attachment (bonding) of the individual pieces shall be electrically continuous. The overlap of the individual *component parts* shall be such as to ensure that the body of the worker is totally covered.

4.2.2 Classification

The *conductive clothing* covered by this document shall be designated as follows:

– by maximum voltage as class 1 (800 kV AC / ±600 kV DC) or class 2 (1000 kV AC / ±800 kV DC);
– by the maximum nominal AC and DC voltage at which the *conductive clothing* can be used (according to the test conditions for *screening efficiency*).

Guidance for the selection of maximum voltage class (AC and DC) is given in Annex A.

NOTE The maximum voltage class 1 corresponds in general criteria to the *conductive clothing* of IEC 60895:2002 (up to 800 kV AC and ±600 kV DC).

4.2.3 Integrity of the conductive clothing

The *conductive clothing* shall be assembled with all its *component parts*. All the connection systems according to the design shall work properly. All the *component parts* shall not be damaged or deteriorated in normal use, and shall be controlled as specified in 5.5.2. This requirement applies to both maximum voltage classes.

4.2.4 Equipotential bonding

All the *component parts* of the complete *conductive clothing* shall be designed to be electrically bonded, and shall be controlled as specified in 5.5.3. This requirement shall respect the value for each maximum voltage class shown in Table 4.

4.2.5 Screening efficiency

The *conductive clothing* shall attenuate the electric field. The attenuation of the *conductive clothing* is determined by *screening efficiency*. This requirement shall be controlled as specified in 5.5.4 and shall respect Table 6 or Table 7.

4.2.6 Spark-discharge protection

To reduce the effect of direct spark discharges, the spacing between any individual adjacent *conductive elements* in the *conductive material* shall not exceed 5 mm under all normal wearing conditions including stretching (such as at the elbows or knees). This requirement shall be controlled as specified in 5.3.7.

This requirement is not applicable to the face screen component.

4.3 Mechanical requirements for the outer layer material

4.3.1 General

The outer layer (conductive or non-conductive – see 4.2.1) of the *garment* and the *component parts* shall have the properties given in 4.3.2 to 4.3.4.

The mechanical characteristics of the conductive helmet and *conductive footwear*, if any, are not covered by this document.

4.3.2 Tear resistance

When the outer layer of the *conductive clothing* is made of woven material, it shall have a tear resistance of at least 15 N (for density higher than 220 g/m^2) or at least 10 N (for density within 150 g/m^2 and 220 g/m^2) in the machine and the cross directions tested according to ISO 13937-2. This requirement applies to both maximum voltage classes.

4.3.3 Burst strength

When the outer layer of the *conductive clothing* is made of knitted material, it shall have a burst strength of at least 1 300 kPa when using an area of (7,3 ± 0,1) cm^2 and a test procedure according to ISO 13938-1. This requirement applies to both maximum voltage classes.

4.3.4 Abrasion resistance

The outer layer material of the *conductive clothing* shall at least resist up to 25 000 abrasion rubs tested according to ISO 12947-2, with an abrasion load of 12 kPa. This requirement applies to both maximum voltage classes.

4.4 Requirements for material

4.4.1 General

The material used to manufacture the *conductive clothing* or the *component parts* shall have the properties given in 4.4.2 to 4.4.6.