

Live working — Flame-resistant materials for clothing for thermal protection of workers — Thermal hazards of an electric arc —

Part 1: Test methods

ICS 13.220.40; 29.260; 29.260.99

National foreword

This Draft for Development is the official English language version of CLC/TS 61482-1:2003.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature as it is an implementation of a CENELEC Technical Specification. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion to a European standard. A review of this publication will be initiated 2 years after its publication by the European organization so that a decision can be taken on its status at the end of its 3-year life. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent in writing to the Secretary of BSI Technical Committee PEL/78, Tools for live working, at British Standards House, 389 Chiswick High Road, London W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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**Live working –
Flame-resistant materials for clothing for thermal protection of workers –
Thermal hazards of an electric arc
Part 1: Test methods
(IEC 61482-1:2002)**

Travaux sous tension –
Matériaux résistant à la flamme pour
vêtements de protection thermique des
travailleurs –
Risques d'arc électrique à effet thermique
Partie 1: Méthodes d'essai
(CEI 61482-1:2002)

Arbeiten unter Spannung –
Flammwidriges Material für thermische
Schutzkleidung –
Wärmefluss des elektrischen Lichtbogens
Teil 1: Prüfverfahren
(IEC 61482-1:2002)

This Technical Specification was approved by CENELEC on 2003-09-08.

CENELEC members are required to announce the existence of this TS in the same way as for an EN and to make the TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the International Standard IEC 61482-1:2002, prepared by IEC TC 78, Live working, was submitted to the formal vote and was approved by CENELEC as a CLC/TS 61482-1 on 2003-09-08 without any modification.

The following date was fixed:

- latest date by which the existence of the CLC/TS
has to be announced at national level (doa) 2004-03-12

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annex B is informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61482-1:2002 was approved by CENELEC as a Technical Specification without any modification.

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LIVE WORKING – FLAME-RESISTANT MATERIALS FOR CLOTHING FOR THERMAL PROTECTION OF WORKERS – THERMAL HAZARDS OF AN ELECTRIC ARC –

Part 1: Test methods

1 Scope

This part of IEC 61482 specifies test methods to measure the arc thermal performance value of materials intended for use in heat- and flame-resistant clothing for workers exposed to electric arcs.

These test methods measure the arc thermal performance value of materials which meet the following requirements: less than 100 mm char length and less than 2 s afterflame after removal from flame, when tested in accordance with ISO 15025, procedure B (bottom-edge ignition) on the outer material, and the char length measured using a modified ISO method as described in annex A.

These methods are used to measure and describe the properties of materials, products, assemblies or garments in response to convective and radiant energy generated by an electric arc in open air under controlled laboratory conditions.

The materials used in these methods are in the form of flat specimens for method A and shirts for method B. Method A is used to measure fabric response to arc exposure when tested in a flat configuration. Method B is used to measure clothing response to an arc exposure including all the garment findings, sewing thread, fastenings, fabrics and other accessories when tested on a mannequin torso.

It is the responsibility of the user of this part of IEC 61482 to establish appropriate safety and health practices prior to use. For specific precautions, see clause 7.

NOTE An alternative test method is under development to measure the same properties using a constrained and directed arc. This method will be added to this part of IEC 61482 when the equivalence to method A has been demonstrated.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 3175-2:1998, *Textiles – Dry cleaning and finishing – Part 2: Procedures for tetra-chloroethene*

ISO 6330:2000, *Textiles – Domestic washing and drying procedures for textile testing*

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

3 Terms and definitions

For the purpose of this part of IEC 61482, the following definitions apply.

3.1

arc duration

time duration of the arc, in s

3.2

arc energy, $vidt$

sum of the instantaneous arc voltage values multiplied by the instantaneous arc current values multiplied by the incremental time values during the arc, in J or kW·s

3.3

arc gap

distance between the arc electrodes, in mm

3.4

arc thermal performance value (ATPV)

in arc testing, incident energy on a fabric or material that results in sufficient heat transfer through the fabric or material to cause the onset of a second-degree burn based on the Stoll curve, in kW·s/m²

3.5

arc voltage

voltage across the arc, V

3.6

asymmetrical arc current

total arc current produced during closure; it includes a direct component and a symmetrical component, A

3.7

breakopen

in electric arc testing, material response evidenced by the formation of one or more holes in the material which may allow flame to pass through the material

NOTE The specimen is considered to exhibit breakopen when any hole is at least 300 mm² in area or at least 25 mm in any dimension. A single thread across the opening or hole does not reduce the size of the hole for the purposes of this part of IEC 61482.

3.8

breakopen threshold energy, E_{BT}

highest incident energy exposure value on a fabric or material below the Stoll curve where the specimens do not exhibit breakopen, in kW·s/m²

3.9

charring

formation of carbonaceous residue as the result of pyrolysis or incomplete combustion

3.10

closure

point on supply current waveform where the arc is initiated

3.11

delta peak temperature

difference between the maximum temperature and the initial temperature of the sensor during the test, in °C

3.12

dripping

in testing flame-resistant clothing, material response evidenced by flowing of the fibre polymer

3.13

embrittlement

formation of a brittle residue as the result of pyrolysis or incomplete combustion

3.14

heat attenuation factor (HAF)

in electric arc testing, per cent of the incident energy which is blocked by a material at an incident energy level equal to ATPV

3.15

heat flux

thermal intensity indicated by the amount of energy transmitted per unit area and time, in kW/m²

3.16

ignitability (ignitable)

in electric arc exposure, property of a material involving ignition accompanied by heat and light, and continued burning resulting in consumption of at least 25 % of the exposed area of the test specimen

3.17

ignition

initiation of combustion

3.18

monitoring sensors

sensors mounted on each side of the panel or mannequin, using the calorimeters described in 6.6, not covered by fabric and used to measure incident energy

3.19

incident energy, E_i

in electric arc testing, heat energy received at a unit surface area as a direct result of an electric arc, in kW·s/m²

NOTE In an arc test, incident energy for a specimen is determined from the average temperature-rise response of the two monitor sensors adjacent to the test specimen.

3.20

material response

material response to an electric arc indicated by the following terms: breakopen, melting, dripping, charring, embrittlement, shrinkage, and ignition

3.21

melting

when testing flame-resistant clothing, material response evidenced by softening of the fibre polymer

3.22**peak arc current**

maximum value of the a.c. arc current, in A

3.23**r.m.s. arc current**

root mean square of the a.c. arc current, in A

3.24**sensor**

device made of a non-conductive heat-resistant material in which the calorimeter is mounted

3.25**shrinkage**

when testing flame-resistant clothing, material response evidenced by reduction in specimen size

3.26**Stoll curve**

curve produced from data on human tissue tolerance to heat and used to predict the onset of second-degree burn injury (see table 1)

3.27**time to delta peak temperature**

time from beginning of the initiation of the arc to the time the delta peak temperature is reached, in s

3.28 **X/R ratio**

ratio of system inductive reactance to resistance. It is proportional to the L/R ratio of time constant, and is, therefore, indicative of the rate of decay of any d.c. offset. A large X/R ratio corresponds to a large time constant and a slow rate of decay

NOTE For definitions of other textile terms used in this part of IEC 61482, refer to ASTM D-123 [5]¹⁾.

4 Principle of the test methods

Both methods determine the incident energy which would predict a second-degree burn injury when the material(s) is(are) exposed to heat energy from an electric arc.

During the tests, the amount of heat energy transferred by the material(s) is measured during and after exposure to an electric arc.

The heat flux of the exposure and that transferred by the test specimen(s) are both measured with copper calorimeters. The rate at which the temperature of the calorimeters increases is a direct measure of the heat energy received.

¹⁾ Figures in square brackets refer to the bibliography.

Material performance for this procedure is determined from the amount of heat transferred by the specimen(s).

Heat transfer data is used to predict the onset of a second-degree burn using the Stoll curve.

The procedures incorporate incident-energy monitoring sensors.

Material response shall be further described by recording the observed effects of the electric arc exposure on the specimens using the terms in 3.20.

5 Significance and use of the test methods

The test methods measure the arc thermal performance value of materials intended for use in flame-resistant clothing for workers exposed to electric arcs. They are intended for the determination of the thermal performance value of a material by itself or in comparison with other materials.

Because of the variability of the arc exposure, different heat transmission values may result for individual sensors. Evaluate the results of each sensor in accordance with clause 12.

The test methods maintain the specimen in a static vertical position and do not involve movement except that resulting from the exposure.

The test methods specify a standard set of exposure conditions. Different exposure conditions may produce different results. In addition to the standard set of exposure conditions, other conditions representative of the expected hazard may be used.

6 Test apparatus

The test apparatus shall consist of the following elements:

- supply bus;
- arc controller;
- recorder;
- arc electrodes;
- three two-sensor panels or one to three four-sensor mannequins;
- monitor sensors for each panel or mannequin.

6.1 Method A – Arrangement of the two-sensor panels

Three two-sensor panels shall be used for each test and spaced at 120° as shown in figure 1. In addition, each two-sensor panel shall have two monitoring sensors. One monitoring sensor shall be positioned on each side of the two-sensor panel as shown in figure 2.

6.2 Panel construction

Each two-sensor panel and monitor sensor holder shall be constructed from non-conductive, heat-resistant material. Each two-sensor panel shall be 200 mm by a minimum of 550 mm as shown in figure 2. Each two-sensor panel and the monitoring sensors shall be adjustable from 200 mm to 600 mm from the centre line of the arc electrodes as shown in figures 1 and 3. Two sensors shall be mounted in the panel as shown in figure 2. Each sensor shall be mounted flush with the surface of the mounting board.

6.3 Method B – Arrangement of the mannequins

Up to three four-sensor mannequins shall be used for each test and spaced at a minimum of 120° as shown in figure 4. Each mannequin shall have two monitoring sensors. One monitoring sensor shall be positioned on each side of the mannequin as shown in figure 5.

NOTE The space around the arc electrodes may dictate the number of mannequins used. It has been found that two mannequins provide the best working space when dressing the mannequins. The minimum 120° spacing should be maintained.

6.4 Method B – Mannequin construction

A male mannequin torso, size large (chest width: 1 067 mm $\pm$ 25 mm), made from non-conductive fibreglass construction shall be used.

The mannequin shall be constructed in an erect posture; the head may be removable; the arms shall be detachable, straight and mounted in a vertical position to allow the test specimen at the chest to be the closest point to the centre line of the arc. The arms may be shortened to 100 mm to permit ease of specimen mounting. The mannequin shall use the sensors described in 6.2 and mounted as shown in figure 6.

6.5 Sensor response

Sensor response shall be compared with the Stoll curve. Monitor sensor response is converted to incident energy in units of kW·s/m² by multiplying the temperature increase (ΔT) by the constant factor 5,65 kW·s/m² K.

6.6 Calorimeter construction

The calorimeter shall be constructed from electrical grade copper with four thermocouple wires installed in the arrangement as shown in figure 7a. The thermocouple wire shall be installed in the calorimeter as shown in figure 7b. Figure 8 gives a typical installation of the calorimeter in the sensor and monitor sensor. For test exposures above 2 512 kW·s/m² only, alternate calorimeters for the monitor sensors may be used, provided they are calibrated and have an appropriate response.

6.7 Supply bus and electrodes

The arrangement of the supply bus and arc electrodes is shown in figure 9. The arc shall be in a vertical position as shown.