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TRAVAUX SOUS TENSION – DISPOSITIFS PORTABLES POUR LA MISE À LA TERRE ET LA CONTINUITÉ DES MASSES

ICS 13.260, 29.240.20, 29.260.99

LIVE WORKING - PORTABLE EQUIPMENT FOR GROUNDING AND BONDING

ICS 13.260, 29.240.20, 29.260.99



Numéro de référence
Reference Number
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This list represents the membership at the time the Committee balloted on the final text of this edition. Since that time, changes in the membership may have occurred.

CAN/ULC-61230-09

(CEI/IEC 61230:2008, IDT)

Travaux sous tension – Dispositifs portables pour la mise à la terre et la continuité des masses

PRÉFACE ULC

Ce document constitue la deuxième édition de la norme, CAN/ULC-61230-09 (CEI/IEC 61230:2008, IDT), *Travaux sous tension – Dispositifs portables pour la mise à la terre et la continuité des masses*, laquelle constitue une adoption, avec les corrections d'ordre rédactionnel canadiennes, de la norme internationale de la Commission Électrotechnique Internationale, CEI/IEC 61230 (Deuxième édition, 2008), *Travaux sous tension – Equipements portables de mise à la terre ou de mise à la terre et en court-circuit*.

Cette édition de la norme a été approuvée par le Comité ULC sur les travaux sous tension et a été approuvée en tant que Norme nationale du Canada par le Conseil canadien des normes.

Une grande partie du financement nécessaire au processus d'adoption de cette norme nationale du Canada a été assurée par l'Association canadienne de l'électricité (ACE) que nous tenons à remercier.

Mars 2009

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CAN/ULC-61230-09 (CEI/IEC 61230:2008, IDT)

Live Working - Portable Equipment for Grounding and Bonding

ULC PREFACE

This is the Second Edition of the Standard CAN/ULC-61230-09 (CEI/IEC 61230:2008, IDT), *Live Working - Portable Equipment for Grounding and Bonding*, which is an adoption, with Canadian editorial changes, of the international standard by International Electrotechnical Commission, CEI/IEC 61230 (Second Edition, 2008), *Live Working – Portable Equipment for Earthing or Earthing and Short-Circuiting*.

This Edition of the Standard has been formally approved by the ULC Committee on Live Working and has been approved as a National Standard of Canada by the Standards Council of Canada.

Major funding in support of the adoption process of this National Standard of Canada was provided by the Canadian Electricity Association (CEA), whose assistance is acknowledged with thanks.

March 2009

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ULC-61230-09

Corrections d'ordre rédactionnel canadiennes

Note : Cette norme ne vise pas les colliers de serrage de poteaux qui feraient normalement partie d'un système de mise à la terre équipotentiel sur des poteaux en bois.

Titre de la norme

[Modifier le titre de la norme, partout dans le texte, comme suit:]

« Travaux sous tension – Dispositifs portables pour la mise à la terre et la continuité des masses »

Terminologie

[Modifier l'expression « mise en court-circuit » quand il s'agit de conducteurs d'interconnexion, comme suit:]

« La modification apportée au texte anglais ne s'applique pas au texte français »

« mise en court-circuit (continuité des masses) »

Généralités

[Réviser les documents de référence comme suit:]

« Changer toutes les références CEI 61477 avec CAN/ULC-61477-05 »

« Changer toutes les références CEI 61318 avec CAN/ULC-61318-08 »

2 Références normatives

[Réviser les documents de référence comme suit:]

« CEI 61477:2001 ou CAN/ULC-61477-05, Travaux sous tension – Exigences minimales pour l'utilisation des outils, dispositifs et équipements »

« CEI 61318:2007 ou CAN/ULC-61318-08, Travaux sous tension – Évaluation de la conformité applicable à l'outillage au matériel et aux dispositifs »

4.9.2 Marquage sur les dispositifs de mise à la terre et en court-circuit

[Réviser la 5^e point comme suit:]

« - le numéro de la norme CAN/ULC applicable avec l'année de publication (CAN/ULC-61230-09) »

Canadian Editorial Changes

Note: This Standard does not address pole bands, which would normally be part of an equipotential grounding system on wooden poles.

Title of Standard

[Revise the title of the Standard and all references within the Standard to read:]

“Live working - Portable equipment for grounding and bonding”

Terminology

[Revise all references to “earthing” and, all references to “short-circuiting” as they are used in relation to interconnecting conductors to read:]

“earthing (grounding)”

“short-circuiting (bonding)”

General

[Revise document references as follows:]

“Change all references to IEC 61477 with CAN/ULC-61477-05”

“Change all references to IEC 61318 with CAN/ULC-61318-08”

2 Normative references

[Revise document references as follows:]

“IEC 61477:2001 or CAN/ULC-61477-05, Live Working – Minimum Requirements for the Utilization of Tools, Devices and Equipment”

“IEC 61318:2007 or CAN/ULC-61318-08, Live Working – Conformity Assessment Applicable to Tools, Devices and Equipment”

4.9.2 Marking on earthing and short-circuiting device

[Revise the 5th item to read:]

“- number of the relevant CAN/ULC standard with the year of publication (CAN/ULC-61230-09)”

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Live working – Portable equipment for earthing or earthing and short-circuiting

Travaux sous tension – Equipements portables de mise à la terre ou de mise à la terre et en court-circuit



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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Live working – Portable equipment for earthing or earthing and short-circuiting

Travaux sous tension – Equipements portables de mise à la terre ou de mise à la terre et en court-circuit

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LIVE WORKING – PORTABLE EQUIPMENT FOR EARTHING OR EARTHING AND SHORT-CIRCUITING

FOREWORD

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International Standard IEC 61230 has been prepared by IEC technical committee 78: Live working.

This second edition cancels and replaces the first edition published in 1993. It constitutes a technical revision.

The major changes are:

- extension of the scope to cover the use of equipment on d.c. installations;
- extension of the use of aluminium to all conductive parts of the device;
- extension of the application to silicone rubber cables made by the revision of TC 20 document IEC 61138;
- possibility of using this standard for separate components of the equipment;
- general revision of requirements and tests;
- deletion of the marking requirement of the double triangle to clarify that the products covered by the standard are not appropriate for performing live working;

- clarification and modification to the procedure for short-circuit test:
 - change of the number of devices submitted to test,
 - change of the pre-conditioning time to 48 h,
 - clarification of the test procedure for separate components,
- application of conformity assessment for products having completed the production phase, according to IEC 61318 Ed.3;
- revision of existing annexes;
- change of normative Annexes A and C into informative Annexes C and B with a reviewed wording;
- deletion of Annex B, not applicable according to IEC 61318 Ed.3;
- deletion of Annex D, its requirements and tests being now included in the body of the standard;
- introduction of a new informative Annex A on railway application;
- introduction of a new informative Annex D giving guidelines for determination of the equivalent r.m.s. value of a short-circuit current;
- revision of the list of type tests, which now appears in normative Annex E;
- introduction of a new normative Annex F on classification of defects.

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

FDIS	Report on voting
78/741/FDIS	78/748/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.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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 International Standard has been prepared in accordance with the requirements of IEC 61477.

An agreement may be made between manufacturer and customer for additional requirements, and tests. These additional requirements are prescribed in the customer's specification on the basis of an acceptance procedure.

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LIVE WORKING – PORTABLE EQUIPMENT FOR EARTHING OR EARTHING AND SHORT-CIRCUITING

1 Scope

This International Standard is applicable to portable equipment, with or without matching connection points, for temporary earthing or earthing and short-circuiting of electrically isolated or de-energized a.c. and d.c. installations, distribution and transmission networks, whether they are overhead or underground or of low or high voltage.

NOTE Annex A provides guidance for application to railway systems.

This standard covers equipment comprising an earthing or a short-circuiting or an earthing and short-circuiting device and insulating component. An example is given in Figure 1a and Figure 1b.

It also covers:

- earthing or short-circuiting or earthing and short-circuiting devices intended to be installed with insulating means. An example of an earthing device is given in Figure 1c;
- separate components, such as conductive extension (see Figure 1b) or clamp or cable with end fittings.

The performance of equipment, devices and components covered by this standard is based on electro-dynamic and electro-thermal effects acting during short-circuit. The withstand capability of the devices and equipment is expressed by their rated values of current, time and peak factor. No rated voltage is given, but the geometrical dimensions of the equipment are also linked to the voltage of the installation.

Examples of connection diagrams of earthing and short-circuiting devices are given in Figures 2 and 3. Associated usual lengths of cables are given in Table 1.

Not covered in this standard are:

- insulating means, such as insulating sticks, telescopic sticks, insulating handles, insulating gloves, aerial devices with insulating booms, insulating ropes to be used to install the earthing and short-circuiting device;
- insulating components, except for basic safety requirements for the insulating element;

NOTE Basic safety recommendations for earthing sticks are given in Annex B.

- devices meant only for the draining of induced currents;
- relevant working procedures for using portable equipment for earthing or earthing and short-circuiting.

NOTE The equipment complying with this standard should be used according to safe working procedures and according to local or national regulation, such as live working or dead working procedures.

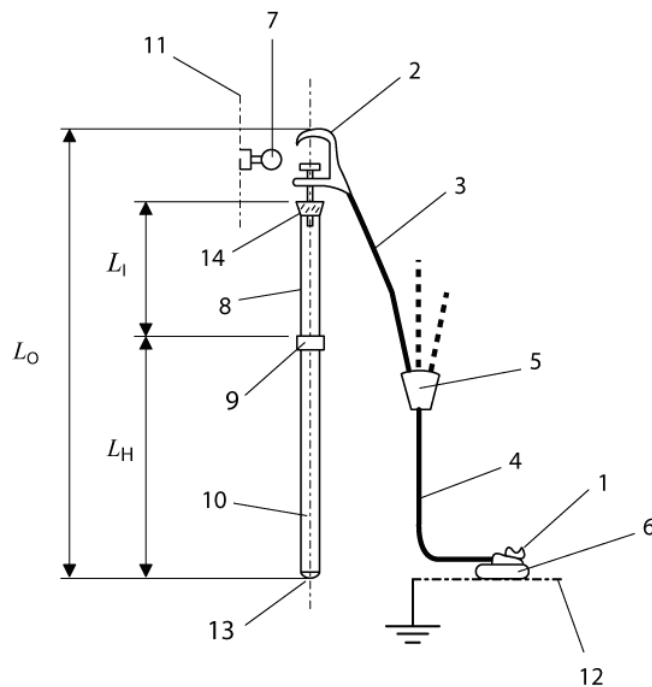


Figure 1a – Multi-phase equipment

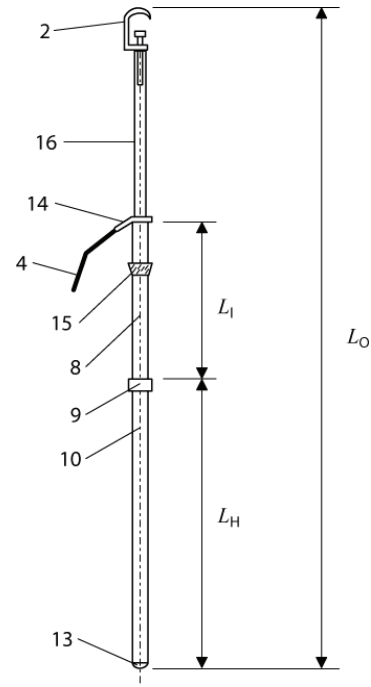
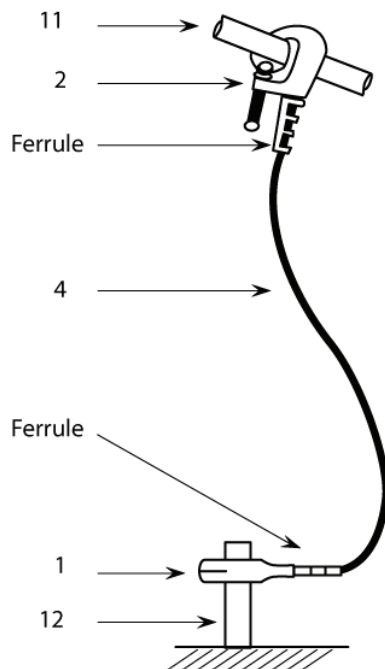


Figure 1b – Single-phase equipment with extension



NOTE The same device can also be used for short-circuiting.

Figure 1c – Earthing device

Key

- 1 Earth clamp or rail clamp
- 2 Line clamp or contact line clamp
- 3 Short-circuiting cable(s)
- 4 Earthing cable(s)
- 5 Connecting cluster
- 6 Earth permanent connection point or rail
- 7 Line permanent connection point or overhead contact line profile
- 8 Insulating element
- 9 Handle limit mark
- 10 Handle of earthing stick
- 11 Installation conductor or bar
- 12 Earthing system
- 13 End cap of stick
- 14 End fitting, permanent or detachable
- 15 Stick coupling, detachable for transport reasons
- 16 Conductive extension
- L_1 Length of insulating element
- L_H Length of handle
- L_O Overall length of earthing stick and conductive extension component

NOTE 1 The earthing and short-circuiting device comprises components 1, 2, 3, 4, 5 and 16.

NOTE 2 The earthing stick comprises components 8, 9, 10, 13, 14 and 15.

NOTE 3 The earthing device comprises components 1, 2 and 4.

Figure 1 – Examples of portable equipment and device for installations, network and railway systems application

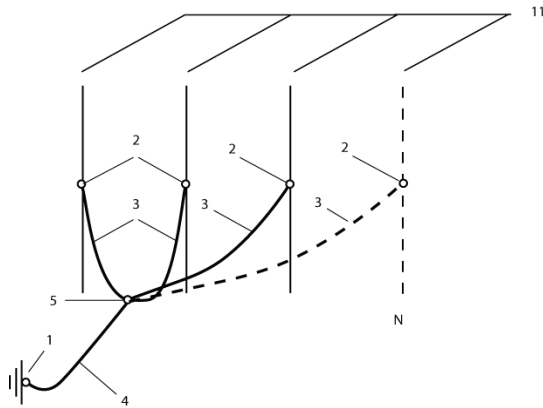


Figure 2a

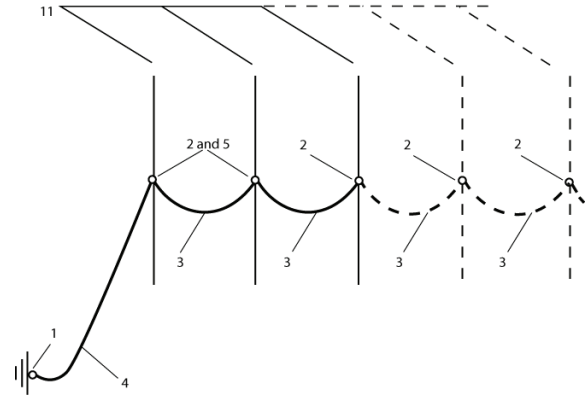


Figure 2b

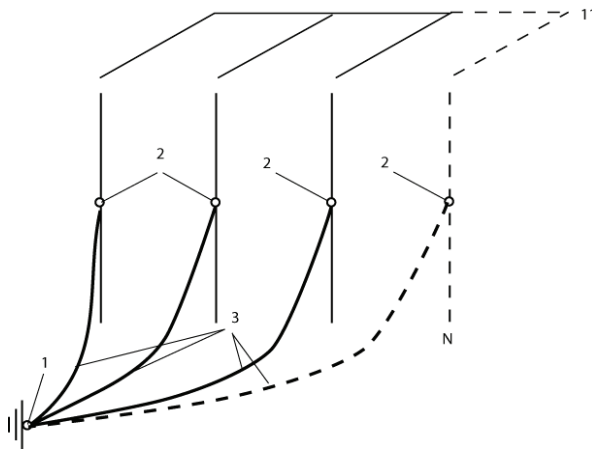


Figure 2c

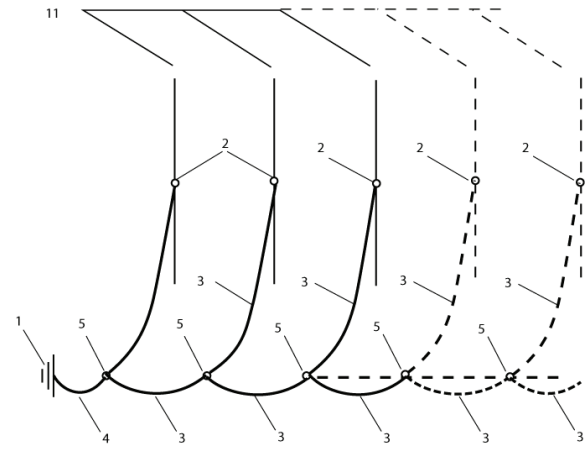
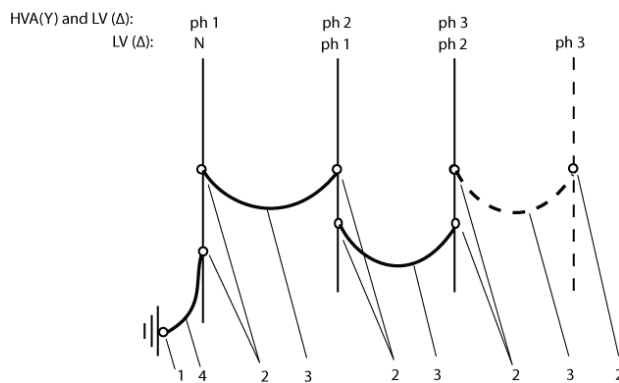


Figure 2d



Key

- 1 Earth clamp
- 2 Line clamp
- 3 Short-circuiting cable(s)
- 4 Earthing cable(s)
- 5 Connecting cluster
- 11 Installation conductor or bar
- 16 Conductive extension

HVA (Y) = High voltage distribution , Y Neutral system

LV (Δ) = Low voltage, Δ Neutral system

Figure 2e

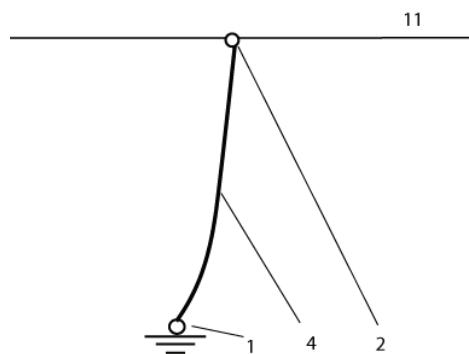


Figure 2f

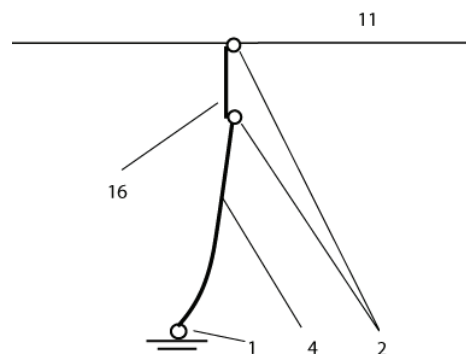


Figure 2g

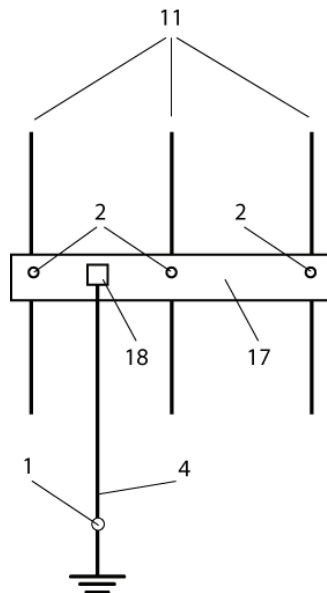
Figure 2 – Connection diagrams of single and multi-phase earthing and short-circuiting devices for network application

NOTE Figure 2 shows examples only of connection arrangements. Not all are suitable for all situations. It is the responsibility of the user to consider movement of connecting cables from magnetic forces. This has to be considered prior to a final connection.

Table 1 – Usual lengths of earthing and short-circuiting cables for different types of installations and different voltage levels

Classes of operating voltages	Overhead line	Open air substation	Metal enclosed or indoor substation
Low voltage ^a	Multi-phase Figures 2a, 2b, 2c, 2d key 3 = 0,5 m key 4 = 12 m to 16 m	Multi-phase Figure 2c ; key 3 = 0,5 m Figure 2a ; key 3 = 0,5 m and key 4 = 1 m to 10 m	Specific
	Single-phase Figure 2f key 4 = 0,5 m to 10 m		
Distribution ^a	Multi-phase Figures 2a, 2b, 2c, 2d key 3 = 2 m to 2,5 m key 4 = 8 m to 10 m	Multi-phase Figures 2a, 2b, 2c key 3 = 7,5m to 10 m key 4 = 2,5 m to 3 m	Multi-phase Figure 2a key 3 = 0,7 m key 4 = 2 m
	Multi-phase + 5 m extension Figure 2g key 4 = 8 m to 10 m		
	Single-phase Figure 2f key 4 = 8 m to 10 m	Single-phase Figure 2f key 4 = 10 m to 12 m	
Transmission ^a	Single-phase Figure 2f key 4 = 8 m	Single-phase Figure 2f key 4 = 10 m to 12 m	Multi-phase Figure 2a key 3 = 3 m key 4 = 3 m
		Single-phase + 2 m to 5 m extension Figure 2g key 4 = 7 m to 8 m	Single-phase Figure 2f key 4 = 3 m to 4 m

^a The voltage limits for the different classes of operating voltage are conventional values and could be modified by national regulations or national practice.



Key

- 1 Earth clamp
- 2 Line clamp
- 4 Earthing cable(s)
- 11 Installation conductor
- 17 Short-circuiting bar
- 18 Earthing cable connection

Figure 3 – Illustration of a three-phase earthing and short-circuiting device with short-circuiting bar and earthing cable(s) for installation and network application

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.

IEC 60060-1:1989 *High voltage test techniques – Part 1: General definitions and test requirements* ¹⁾

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests – Test Ka: Salt mist*

IEC 60068-2-42:2003, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature*
Amendment 1 (1993)
Amendment 2 (2001)

¹⁾ Under revision.

IEC 60811-2-1:1998, *Insulating and sheathing materials of electric and optical cables Common test methods – Part 2-1: Methods specific to elastomeric compounds – Ozone resistance, hot test and mineral oil immersion tests*
Amendment 1 (2001)²⁾

IEC 60811-3-1:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section One – Pressure test at high temperature – Tests for resistance to cracking*
Amendment 1 (1994)
Amendment 2 (2001)

IEC 61138:2007, *Cables for portable earthing and short-circuiting equipment*

IEC 61318:2007, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 61477:2001, *Live working – Minimum requirements for the utilization of tools, devices and equipment*
Amendment 1 (2002)
Amendment 2 (2004)³⁾

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318 and the following apply.

NOTE Further information on terminology is illustrated in Figures 1, 2 and 3.

3.1

conductive extension

rigid conductor forming an extension of an earthing or short-circuiting or earthing and short-circuiting device

NOTE The conductive extension can be installed between the end fitting of an earthing stick and a line clamp, or between a line clamp and connecting point.

[IEC 60743, definition 15.9, modified; IEC 651-14-11, modified]

3.2

connecting cluster

component of an earthing and short-circuiting device for connecting short-circuiting cables either directly or through connecting links, such as cable lugs, to each other and to the earthing cable(s) and/or the earth clamp

[IEC 60743, definition 15.5, modified; IEC 651-14-06, modified]

3.3

connecting point

part of installation or part of test set-up to which a clamp is connected

²⁾ There exists a consolidated edition 2.1 (2001) that includes IEC 60811-2-1:1998 and its Amendment 1.

³⁾ There exists a consolidated edition 1.2 (2005) that includes IEC 61447:2001 and its Amendments 1 and 2.

3.4

connection point

part of installation specially arranged for clamp connection (for example, ball pin, cylinder bolt, bow, hook, stirrup, stud)

[IEV 651-14-09 modified]

3.5

dead (in live working)

de-energized

at a potential equal to or not significantly different from that of earth at the worksite

NOTE In some countries, according to the dead procedures, the state dead is only considered after the earthing and short-circuiting equipment has been properly installed.

[IEV 651-01-15 modified]

3.6

earth clamp

clamp forming part of an earthing or earthing and short-circuiting device for connecting an earthing cable, or a connecting cluster to an earthing conductor or an earth electrode or a reference potential

[IEC 60743, definition 15.6, modified; IEV 651-14-07, modified]

3.7

earthing and short-circuiting device

assembly of components for interconnecting conductors for earthing or short-circuiting or earthing and short-circuiting installations and networks

NOTE 1 The earthing and short-circuiting device comprises clamps, cables or bars and possibly clusters.

NOTE 2 The earthing and short-circuiting device could be of single phase type or multi-phase type.

[IEC 60743, definition 15.2, modified; IEV 651-14-03, modified]

3.8

earthing cable

cable forming part of an earthing and short-circuiting device, which connects earth clamp to a line clamp of the electrical installation or earth clamp to connecting cluster

[IEC 60743, definition 15.1, modified; IEV 651-14-02, modified]

3.9

earthing stick

earth application stick

insulating component equipped with a permanent or detachable end fitting for installing clamps, short-circuiting bars or conductive extension components onto the electrical installation

NOTE The insulating element of the earthing stick is intended to provide the adequate safety distance and insulation to the worker.

[IEC 60743, definition 15.8, modified; IEV 651-14-10, modified]

3.10**energized** (in live working)

at a potential significantly different from that of earth at the worksite and which presents an electrical hazard

NOTE A part is energized when it is electrically connected to a source of electric energy. It can also be energized when it is electrically charged under the influence of an electric or magnetic field.

[IEV 651-01-14]

3.11**induced current**

electric current resulting from the displacement of charges carriers due to an induced tension or a magnetic field induction

[IEV 121-11-29 modified]

3.12**insulating element**

element of an insulating component that provides adequate electrical insulation to the worker

NOTE For most of the insulating components used in the design of portable equipment for earthing or earthing and short-circuiting, the insulating element also provides adequate safety distance to the workers.

3.13**insulating component**

hand-held insulating part of a portable equipment for earthing or earthing and short-circuiting, designed to bring and connect clamps to parts of electrical installations

NOTE An earthing stick is considered as an insulating component.

3.14**insulating means**

insulating tool, equipment or device, manual or mechanical, complying with insulating properties and used for bringing and connecting clamps of earthing and short-circuiting devices to parts of electrical installations

NOTE An insulating glove, an insulating rope, an insulating handle, an insulating stick, an insulating telescopic stick, an aerial device with insulating boom, are insulating means.

3.15**insulating stick**

insulating tool essentially made of an insulating tube and/or rod with end fittings

[IEV 651-02-01]

3.16**isolate**

to disconnect completely a device or circuit from other devices or circuits, separating it physically, electrically and mechanically from all sources of electrical energy

NOTE Such separation may not eliminate all effects of electromagnetic or electrostatic induction.

[IEC 61328, definition 3.46, modified; IEC 61911, definition 3.39, modified]

3.17

line clamp

clamp forming part of an earthing and short-circuiting device, which is attached to a short-circuiting cable, a short-circuiting bar or conductive extension component, either directly or through connecting links, and used for the connection to line (line conductors, busbars or current-carrying conductors), or to the connection point

[IEC 60743, definition 15.7, modified; IEC 651-14-08, modified]

3.18

maintenance test

test carried out periodically on an item to verify that its performance remains within specified limits, after having made certain adjustments, if necessary

[IEC 151-16-25]

3.19

maximum peak current

i_{tm}

peak value associated with the first major loop of the test short-circuit current determining the highest electro-dynamic mechanical stresses

3.20

portable equipment for earthing or earthing and short-circuiting

equipment, which is portable and is capable to be carried by one person and manually or mechanically connected with its insulating component to parts of an electrical installation for earthing or short-circuiting or earthing and short-circuiting purposes

NOTE 1 The portable equipment for earthing or earthing and short-circuiting comprises the earthing and short-circuiting device and one or more specific detachable or non-detachable insulating components.

NOTE 2 The use of insulating component is to safely connect the devices to the connecting points.

NOTE 3 The portable equipment for earthing or earthing and short-circuiting is installed temporarily on isolated power circuits for the purposes of potential equalization and to help protect the worker by conducting a short-circuit current for a specified duration (time).

NOTE 4 The aim of the earthing and short-circuiting of disconnected or isolated parts of installations is to provide a control path to the short-circuit current and secondly to prevent the voltage rise in the earth circuit.

[IEC 651-14-01 modified]

3.21

rated current and rated time

r.m.s value of current and time assigned to a device, or component, determining the highest mechanical and thermal stresses for a given peak factor

NOTE The values apply only to those parts designed to withstand short-circuit current.

[IEC 651-14-12 modified]

3.22

rated peak factor

ratio of the maximum peak current to its rated current

[IEC 101-14-57 modified]

3.23

safety distance

air clearance between the worker and a live part of the installation related to the voltage of the installation and to the working procedures, which is determined to prevent any electrical hazard to occur



3.24**short-circuiting bar**

rigid conductor, such as a bar or tube, forming part of an earthing and short-circuiting device which connects together phases of the installation

[IEC 60743, definition 15.4, modified; IEV 651-14-05, modified]

3.25**short-circuiting cable**

cable forming part of an earthing and short-circuiting device, which connects together clamps to a common electrical reference point such as a line clamp to another line clamp or to a connecting cluster

[IEC 60743, definition 15.3, modified; IEV 651-14-04, modified]

3.26**solidly earthed (neutral) system**

system whose neutral point(s) is (are) earthed directly

[IEV 601-02-25]

3.27**supplier**

organisation or person that provides a product

Example: Producer, distributor, retailer or vendor of a product, or provider of a service or information.

NOTE 1 A supplier can be internal or external to the organisation.

NOTE 2 In a contractual situation a supplier is sometimes called “contractor”.

[ISO 9000, definition 3.3.6]

3.28**transit current**

current which flows through the cables of the earthing and short-circuiting device when the device is completely connected to the electrical installation

NOTE 1 For HV installations or networks, the current may be a residual current (e.g. unbalanced load or induced current).

NOTE 2 For railway d.c. systems, the current flowing from the rail to the overhead contact line when the earthing cable is connected and when a train is running on an adjacent rail track.

4 Requirements**4.1 General**

The equipment, devices and components shall be designed to contribute to the safety of the users provided the equipment, devices and components are used by skilled persons, in accordance with safe methods of work and the instructions for use (see 4.10).

NOTE 1 According to safe procedure, electrical installations are considered energized or live until all protective earthing and short-circuiting equipment have been properly installed.

NOTE 2 Where applicable, national or regional regulations should be followed, such as live working or dead working procedures.

Earthing and short-circuiting devices and their components shall be designed to withstand all the mechanical stresses to which they are submitted during normal use.

Devices and components shall withstand the maximum short-circuit current, time and Joule integral for which they are rated.

NOTE Devices and components should be designed in order to also accept transit current.

Earthing and short-circuiting devices, when installed according to instructions for use, shall be able to withstand all stresses from short-circuit currents for which they are designed without causing electrical, mechanical, chemical or thermal danger to persons.

NOTE 1 For indoor use and enclosed space, poisonous effects should be considered (see C.2.2).

NOTE 2 Highest possible temperature rise of cables is therefore adopted to reduce weight.

The manufacturer or the end assembler of all component parts of the equipment shall be responsible to ensure that the equipment meets all the requirements of this standard.

4.2 Electrical rating

Earthing and short-circuiting devices and their components shall be rated in terms of a short-circuit current (I_r), a time (t_r) and the corresponding peak factor.

For d.c. applications, the values shall be the same.

Most common values for the rated time are the following:

3 s, 2 s, 1 s, 0,75 s, 0,5 s, 0,25 s, 0,1 s

The rating of the complete device shall be expressed as rated current in kiloamperes, as rated time in seconds and rated peak factor (see 4.9).

NOTE In order to compare different rated values see Annex C.

Separate components of the equipment shall be provided with their rated values and their corresponding test configurations (see 4.10).

Compliance shall be verified by visual verification according to 5.2.

4.3 Cables for earthing and short-circuiting

Earthing and short-circuiting cables, whether they are made of aluminium or aluminium alloy or made of copper, shall be designed to meet the performance requirement of their rating.

NOTE For selection of the cable cross-section according to temperature rise during a short-circuit, curves or tables and guidance are given in Annex C.

Cables shall have adequate mechanical, chemical, environmental and electrical properties to meet all the requirements of this standard.

NOTE 1 It may be acceptable that the insulating covering of the cable may melt or burn according to the maximum accepted temperature rise during the flow of the short-circuit current and according to the applicable safety rules.

NOTE 2 Guidance for selection of cables taking into account transit current is given in Annex C.

4.3.1 Selection of cables

Cables for earthing and short-circuiting purposes (see Figures 1, 2, and 3) shall be flexible.

Cables shall be insulated for mechanical protection.

NOTE The customer may request additional resistance to mechanical shock onto a metallic structure. The cable with PVC insulation should meet the additional requirement and clashing test of 5.4 of IEC 61138.

The selection of the nature of the insulating material shall be made to fulfil chemical, environmental and temperature conditions met in practice.

For earthing and short-circuiting cables of a circular cross-section, electrical, mechanical and other requirements can be met by selecting cables according to IEC 61138.

Cables not complying with IEC 61138 can be used but shall fulfil the following tests:

- the flexibility shall be in accordance with 5.3 of IEC 61138, and with 8.2 of IEC 60811-1-4 for low temperature bending test,
- the physical integrity of the cover shall be in accordance with 5.1.3 of IEC 61138,
- the type of insulating material shall be in accordance with Clause 7 of IEC 61138,
- the resistance to mechanical shock shall be in accordance with 4.3.5 of IEC 61138.

Compliance for selection shall be verified by visual verification of the conformity to IEC 61138 or shall be verified by tests according to 5.3.2.

4.3.2 Earthing cables used on solidly earthed (neutral) systems

Earthing cables used on solidly earthed systems shall have the same cross-section as the associated short-circuiting cables or bars.

4.3.3 Earthing cables used on non-solidly earthed (neutral) systems

Earthing cables used on non-solidly earthed systems may have a cross-section less than the corresponding short-circuiting cables or bars, but never less than that given in Table 2. For values in between those listed in the first column, the value of the second column shall be the next higher size.

Table 2 – Minimum cross-section of earthing cables related to the cross-section of the short-circuiting cables and/or bars on non-solidly earthed (neutral) systems

Copper equivalent cross-section of short-circuiting cables and/or bars mm ²	Minimum copper equivalent cross-section of earthing cables mm ²
16	16
25	16
35	16
50	25
70	35
95	35
120	50
150	50

4.4 Short-circuiting bars

Short-circuiting bars, whether they are made of aluminium or aluminium alloy or made of copper, shall be designed to meet the performance requirement of their rating.

They shall be designed to be compatible with the installation on which they may be positioned. For this purpose, dimensions of short-circuiting bars are not standardised.

Compliance shall be verified by manual checking according to 5.2 and by test according to 5.7.

4.5 Connections of cables to rigid parts within devices

Excellent fatigue resistance is required for the connections of cables to rigid parts (ferrules, cable lugs, end fittings, clusters, etc.).

The connections shall be made with great care to ensure that the specified minimum characteristics of the cables are maintained. Soldered connections are not permitted.

The connection between end fittings and cables shall be protected from water penetration.

All attachments shall be protected against unintentional loosening. Single screws or nuts, if used, shall always be combined with a device, for instance lock washers, that positively prevents slippage or rotation.

Ferrules, cable lugs, end fittings, etc., shall have at least a current-carrying capacity equivalent to the associated cables.

Compliance shall be verified by visual verification according to 5.2 and by tests according to 5.4, 5.5 and 5.7.

4.6 Clamps

Clamps shall be designed to withstand the stresses for which they are rated. They shall provide reliable contact performance and shall withstand the thermal and mechanical stresses produced by the rated short-circuit currents.

Line and earth clamps shall be suitable for the surface and shape of the connecting point and shall permit easy and safe installation without causing damage to clamps and without danger for personnel.

For tightening type, the manufacturer or the end assembler shall provide a rated torque which shall be properly defined for the installation.

For other types such as spring clamps they shall not require an unusual force during the positioning and the removing operations.

NOTE More than one spring clamp may be put on the top end of an earthing stick for a quick and multiple operation. For this reason it is allowed to have specific or additional positioning device for holding many clamps.

Each different design of clamp of the same rating shall be type tested in the same conditions in order to be considered equivalent.

Compliance shall be verified by manual checking according to 5.2 and by tests according to 5.6 and 5.7.

4.7 Earthing and short-circuiting device

The different components of an earthing and short-circuiting device may come from the same manufacturer or from different manufacturers. The final assembly shall be made under the responsibility of the manufacturer or the end assembler of the device. Manufacturer or supplier of separate components shall give sufficient information in order to maintain the capability of the complete device. The final quality of the device after assembly relies only on its end assembler.

A earthing and short-circuiting device can use cables in parallel as short-circuiting or earthing cables.

For a multi-phase earthing and short-circuiting device, all cables exposed to a rated short-circuit current shall have the same cross-section, but the earthing cable(s) may have a smaller cross-section in case of use on non-solidly earthed system (see Table 2).

Compliance shall be verified by verification and checking according to 5.2 and by test according to 5.7.

4.8 Basic safety requirements for the insulating element(s) of the insulating component

The insulating element(s) of the insulating component (earthing stick or other type) shall make use of insulating material(s) and shall be designed such as to provide basic electrical insulating properties to permit the workers to establish the appropriate electrical insulation when installing and removing the portable equipment for earthing or earthing and short-circuiting.

The manufacturer shall identify the design parameters associated with the basic insulating properties of the insulating element.

NOTE 1 Many parameters of a design of insulating element influence its overall insulating performance. Some parameters are under the control of the manufacturer. Others (ex: the length of insulating tube or rod) may be influenced by working procedures, regional or national regulations. The basic insulating properties are here associated with the design parameters controlled by the manufacturer.

NOTE 2 For example, when cylindrical tubes or rods are used as raw material for the design of the insulating element of an earthing stick, a design parameter associated with the basic electrical properties is the appropriate selection of tubes or rods according to IEC 60855 or IEC 61235.

Annex B provides guidance for selection of the insulating element of the earthing stick as a type of insulating component of complete equipment.

Compliance to the basic safety requirements shall be verified by verification according to 5.2.

4.9 Marking

4.9.1 General

The marking shall be clearly legible. It shall be durable and not removable.

Each device, cable and clamp shall be marked properly.

When a device is made of several components of different rating, the marking of the rated values of the device shall be the minimum of the rated capacity of each component and under the responsibility of the final assembler.

NOTE Additional recommendations are given in Annexes B and C.

Compliance shall be verified by visual verification according to 5.2 and by test according to 5.8.

4.9.2 Marking on earthing and short-circuiting device

The device itself or an additional non-removable label shall be marked where appropriate with at least the following items of marking:

- manufacturer's name or trade mark or end assembler's name;
- model or type reference for the device;
- year of manufacture;

- rated current I_r (kA), rated time t_r (s) of the device and value of the rated peak factor (for example 10 kA – 0,5 s – 2,6);
- number of the relevant IEC standard.

4.9.3 Marking on clamp

Clamp itself or an additional non-removable label shall be marked with at least the following items of marking:

- manufacturer's name or trademark;
- model or type reference for the clamp.

4.9.4 Marking on cable

For cables covered by IEC 61138, no other marking is required.

NOTE The reference number of the cable standard is given by the code designation.

For cables not covered by IEC 61138, the cable shall be marked with the following items:

- indication of the origin of the cable (see 4.4.1 of IEC 61138);
- cross-section or cable size;
- nature of the insulating covering (see Clause 7 of IEC 61138).

4.9.5 Marking on other components

Other components such as short-circuiting bars or conductive extension of the earthing and short-circuiting devices may be delivered separately. In that case they shall be marked similar to the clamps.

4.10 Instructions for use

Each device or equipment covered by this standard shall be supplied with manufacturer's written information and instructions for use and care. These instructions shall be prepared in accordance with the general provisions given in IEC 61477.

They shall include at least the following:

- instructions for assembling the complete device or equipment;
- limitation, if any, of the main characteristics such as rated values, temperature conditions, indoor use, etc.;
- rated values (current, time and peak factor) of the separate components;
- guidelines for maintenance, use, storage and inspection;

NOTE Users should also refer to Annex C for additional information.

- torque and force values and instructions for securing of auxiliary fasteners, which may loosen during use;
- information about the use of aluminium for cables, clamps and other parts of the devices, if relevant;
- statement that "the devices shall be removed from service after exposure to short-circuit current" (see C.4);
- number of the relevant IEC standard and the year of publication with amendment, if any.

NOTE Additional instructions for use may be requested by the customer.

Compliance shall be checked by visual verification according to 5.2.

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5 Tests

5.1 General

The present standard provides testing provisions to demonstrate compliance of the product to the requirements of Clause 4. These testing provisions are primarily intended to be used as type test for validation of the design input. Where relevant, alternative means (calculation, examination, tests, etc.) are specified within the test subclauses for the purpose of portable equipment for earthing or earthing and short-circuiting having completed the production phase.

The list of type tests to be performed with references to corresponding subclauses is specified in Table E.1 of Annex E.

Tests shall be carried out at the responsibility of the manufacturer or end supplier.

Tests shall be carried out at temperatures between $-10\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$ and regardless of humidity, unless otherwise specified.

NOTE 1 This broad range of climatic conditions is specified because outdoor testing may often be preferable or necessary.

NOTE 2 A maximum temperature of $+45\text{ }^{\circ}\text{C}$ should be accepted in case of outdoors tests in countries where usual temperatures are very high.

Electrical tests shall be carried out using a single-phase a.c. voltage source in accordance with IEC 60060-1. The test circuit shall be complemented by adequate transformers and impedances to generate the test short-circuit current in order to fulfil the requirements of 5.7.

NOTE 1 It is recommended to consider IEC 62475 Ed.1 for high current test techniques (under development).

NOTE 2 For d.c. current tests there is no prescribed reference for the d.c. source. It is common practice to use the same rms a.c. value and set up.

Components evaluated by destructive tests shall not be re-used.

Visual verification shall be made either on complete equipment or device or separate components.

The manufacturer or the final assembler shall provide the test pieces. Test pieces intended to be used for destructive tests shall be prepared from complete equipment or device.

Unless otherwise specified, the type tests shall be carried out on three separate test pieces or complete devices.

The tests shall be considered as passed when all test pieces or the complete devices pass the tests.

NOTE For products having completed the production phase, the tests associated with critical, major and minor defects are specified in Annex F (also see Clause 6)

Acceptance tests are covered by IEC 61318.

5.2 Verification and checking

When visual verification is specified, it shall be understood to be visual verification by a person with normal or corrected vision without additional magnification.

Visual and dimensional verification, manual checking and other verification shall be made to check if the relevant requirements of Clause 4 are fulfilled.

The verification and checking shall be considered as passed if all the relevant requirements of Clause 4 are fulfilled.

5.3 Tests for the selection of cables

5.3.1 Cables complying with IEC 61138

In order to verify that cables comply with IEC 61138, visual verification shall be made on the marking of the cable.

5.3.2 Cables not complying with IEC 61138

5.3.2.1 Type tests

Cables not complying with IEC 61138 shall fulfil the following tests:

- for flexibility, 5.3 of IEC 61138, and with 8.2 of IEC 60811-1-4 for low temperature bending test,
- for the type of insulating material, Clause 7 of IEC 61138,
- for the resistance to mechanical shock:
 - for EPR, Clause 9 of IEC 60811-2-1,
 - for PVC, 9.2 of IEC 60811-3-1,
 - for PVC ST11, 9.2 of IEC 60811-3-1 and Table 7 of IEC 61138,
 - for SiR, Clause 9 of IEC 60811-2-1 and Table 8 of IEC 61138,
- for clashing, if required, 5.4 and Annex A of IEC 61138.

5.3.2.2 Alternative test for conformity assessment during production phase

The physical integrity of the cover shall be checked according 5.1.3 of IEC 61138.

5.4 Fatigue and humidity penetration tests on cable with end fittings

5.4.1 Fatigue test

Each type of cable with its end fittings shall be subjected to a combined bending and twisting test on three test pieces.

The test arrangement is shown in Figure 4. The metal bar or screw which forces the rotation shall be made either of steel, brass or aluminium alloy. The shape of the screw shall be made with care in order to obtain a uniform movement.

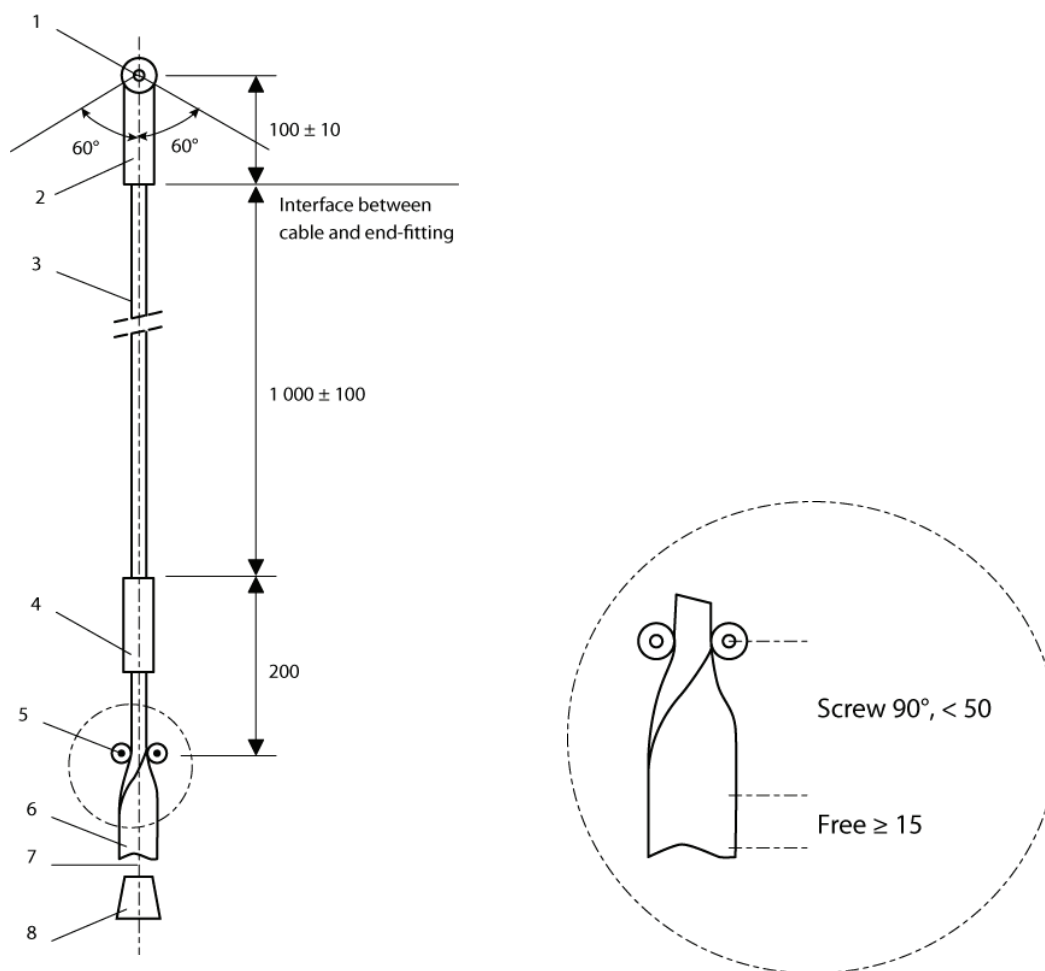
A test piece consists of a cable and end fittings. The free length of the cable shall be $1\,000\text{ mm} \pm 100\text{ mm}$. The end fitting of the upper end of the cable shall be mounted vertically in a test apparatus so that it can be oscillated around a horizontal axis, at 60° in both directions from the vertical. The interface between the cable and the end fitting shall be $100\text{ mm} \pm 10\text{ mm}$ from the axis (see Figure 4).

The lower end of the cable shall be attached to a vertical, guided screw and loaded with an appropriate mass in order to obtain a resulting force greater than or equal to $0,5\text{ N per mm}^2$ of copper cable conductor cross section and $0,15\text{ N per mm}^2$ of aluminium cable conductor cross section.

During one half-cycle of the test, the cable shall be twisted 90° in its unwinding direction, and back again. The duration of one cycle shall be at least 5 s. The test shall be terminated after 1 000 cycles. The starting position shall be vertical.

The humidity penetration test shall then be performed according to 5.4.2.

Dimensions in millimetres

**Key**

- 1 Axis of oscillation
- 2 End-fitting
- 3 Cable
- 4 End-fitting or tight connection between cable and item 6
- 5 Guide rolls, free distance $6 \text{ mm} \pm 1 \text{ mm}$
- 6 Metal bar, $40 \text{ mm} \times 5 \text{ mm}$
- 7 Wire
- 8 Weight to obtain a resulting force = $0,5 \text{ N per mm}^2$ of copper cable conductor cross section or $0,15 \text{ N per mm}^2$ of aluminium cable conductor cross section

Figure 4 – Apparatus for fatigue testing with bending and twisting

The sanction of the fatigue test shall be made after the humidity penetration test.

For verification of the conductor after test, the cable insulation of the upper end shall be removed and the conductor unwound into single strands, since damage to the conductor may start in the inner parts.

The fatigue test shall be considered as passed if:

- no cracks or wrinkles are observed on the cable insulation;
- no more than 1 % of the conductor strands are broken.

5.4.2 Humidity penetration test

The test shall be carried out after the fatigue test specified in 5.4.1 and using the same test pieces.

5.4.2.1 Test procedure

The test piece shall be completely immersed in a solution, which is specified in 5.4.2.2 for copper cables and in 5.4.2.3 for aluminium cables.

For copper cables the test piece shall be completely immersed for at least 45 min and be maintained for at least 15 min in each of three different positions similar to the two extreme positions and the middle position of the fatigue test.

For aluminium cables the test piece shall be completely immersed for at least 240 min and be maintained for at least 80 min in each three different positions similar to the two extreme positions and the middle position of the fatigue test.

At the end of the humidity penetration test, the cable insulation of the upper end shall be removed for inspection.

The humidity penetration test shall be considered as passed if the copper conductor has not turned black or if the aluminium conductor has not turned brown.

5.4.2.2 Sodium sulphide solution for copper cable

The humidity penetration test for copper cables shall be carried out with a sodium sulphide solution, prepared as follows:

600 g of sodium sulphide ($\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$) shall be dissolved in 3 l of water and stirred together with an excess quantity (at least 750 g) of flowers of sulphur for at least 6 h at a liquid temperature of 40 °C. Allow the un-dissolved sulphur to settle for at least a further 6 h and filter the solution. Adjust the density to 1,142 g/cm³ by adding distilled water or saturated sodium.

Before use, the quality of the sodium sulphide solution shall be verified. A piece of bare copper wire shall turn black in 5 s or less, when immersed in the solution.

5.4.2.3 Permanganate potassium solution for aluminium cable

The humidity penetration test for aluminium cables shall be carried out with a permanganate solution, prepared as follows:

3 g of permanganate shall be dissolved in 3 l of water and stirred together.

Before use, the quality of the permanganate solution shall be verified. A piece of bare aluminium shall turn brown in 4 h or less, when immersed in the solution.

5.5 Tension test on cable with end fittings

Each combination of cable to end fittings shall be tested using three test pieces.

Each test piece, with a free length of cable of 50 cm ± 5 cm and with its end fittings shall be subjected to a tension force increasing linearly during at least 10 s up to the corresponding value given in Table 3 (for example with a copper cable of 75 mm² rated conductor cross-

section, the tension force N is: $80 \times 75 = 6\,000\text{ N}$). The specified tension force shall be held for 30 s and then removed. The tension shall be applied along the cable axis.

The test shall be considered as passed if no connection has loosened.

Table 3 – Tension test force on cable with end fittings

Cross-section area of conductor A^a mm^2	Tension force Copper N	Tension force Aluminium N
≤ 50	$100 \times A$	$60 \times A$
> 50	$80 \times A$	$50 \times A$

^a "A" = the rated cross-section area of the conductor

5.6 Test on clamps, permanent connection points and connections

Clamps shall be tested by connecting them to fixed connection points or to conductors with dimensions, shapes and surfaces for which they are designed, using the connecting method recommended by the manufacturer.

The testing of clamps designed for a range of conductor sizes or for connection points shall consist of two tests with the largest and two tests with the smallest conductor or connection point.

5.6.1 Tests for tightening types

A torque shall be applied to the screw of the clamp progressively, up to a value of 1,25 times the rated tightening force T_r given by the manufacturer and then maintained at this value for a period not less than 1 min.

NOTE The rated value should be defined taking into account the most severe application.

The test shall be considered as passed if no damage such as cracks or deformation is seen on the clamp during visual verification after test.

5.6.2 Tests for non-tightening types

For non-tightening type of clamps, there is no test required. There is no way to overstress the clamp during installation.

5.7 Short-circuit current test

5.7.1 General

The electromagnetic forces on the device during a short-circuit depend on the configuration of the installation, the location of connecting points and, for cable devices, the cable length in relation to the distance between the connecting points. The short-circuit current test shall simulate the worst stresses that a device may be exposed to in practice.

The short-circuiting part of single phase or multi-phase earthing and short-circuiting devices shall be tested on test set-ups simulating phase to phase or phase to earth.

For devices used on non-solidly earthed (neutral) systems, the value of short-circuit current, corresponding to the earth fault, shall be applied to the earthing cable accordingly.



NOTE If required by the customer, the test may be made on a three-phase set-up corresponding to the installation to be earthed or in the real configuration of the installation. Three-phase sources may be used after agreement between manufacturer and customer with the frequency corresponding to the installation.

In case of equipment, the insulating component(s) that are detachable are not submitted to test while non-detachable insulating component(s) shall be submitted to test.

Depending on the design of the clamps, tests shall be performed in different ways:

- a) When the device is designed for only one size of conductor or only one shape and dimension of connection point, the test shall be performed three times for this conductor or for this connection point, each time with a different test piece.
- b) When the device is designed for a range of conductor sizes that a clamp may be attached to, four tests shall be performed each time with a different test piece. Two tests shall be performed with the maximum conductor size at the rated current of the device. Two tests shall be performed with the minimum conductor size at the rated current of the conductor of minimum size.
- c) When the device is designed to be used for different shapes of connection points, the test shall be performed twice for each shape for which the clamp is designed, each time with a different test piece.
- d) In case of clamps accommodating different shapes and different sizes of connection points, each shape and each size shall be tested twice on the maximum current and twice on the minimum current, each time with a different test piece. Examples of combinations are given in Figure 5.

All tests in standard test set-ups shall be performed with a.c. single-phase or single path current at a frequency selected between 45 Hz and 65 Hz for network and installation application.

NOTE A.C. short-circuit application is more severe than d.c. short-circuit. Consequently, a device or equipment tested in a.c. could be used in d.c. with the same value of rated current. After agreement between customer and manufacturer, the customer could require a d.c. test made according to his own specification.

All varieties of current paths between connecting points that may be exposed to short-circuit current shall be subjected to test at least twice. The total number of tests depends on the type of devices as explained above. Devices which are specified for use in solidly earthed systems shall thus be tested line to earth as well as line to line.

For multi-phase devices using cables connected in parallel, when a separate clamp is used for each cable, tests shall be performed with the clamps connected as close together as possible.

For separate components, they shall be assembled in a device test piece and submitted to short-circuit current test. The manufacturer shall provide documentation on the test set-ups used to qualify the separate components.

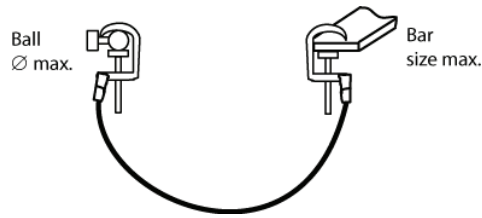


Figure 5a – Combination of ball and bar of maximum size

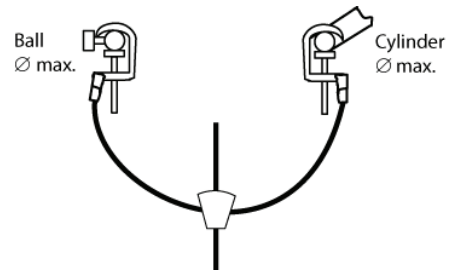


Figure 5b – Combination of ball and cylinder of maximum size

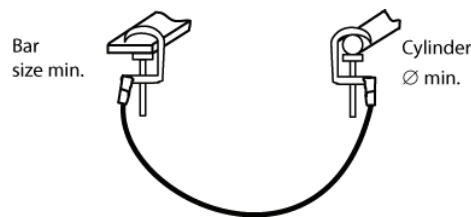


Figure 5c – Combination of bar and cylinder of minimum size

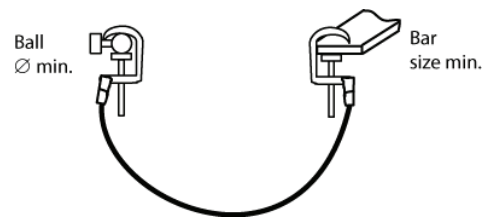


Figure 5d – Combination of ball and bar of minimum size

NOTE In Figures 5a, 5c and 5d, cables may be short-circuiting cables or earthing cables.

Figure 5 – Examples of multiple combinations of clamps accommodating different shapes and sizes of connection points

5.7.2 Preparation of test pieces

If the branches of multi-phase devices are not identical, the test shall be carried out with those having the greatest number of contacts in the current path, clamp to clamp. Other branches affecting the test, for instance using the same earth fixed connection point, shall also be included. A new test piece or a different test piece shall be used for each test. For example for three tests we need three test pieces.

5.7.2.1 Dimensions

Dimensions of test pieces are specified in Figures 6, 7 and 8. Dimensions could be according to Table 1 for specific use. Lengths of interconnecting cables and conductive extension, if any, exclude clamps and connecting clusters, unless specifically indicated. These lengths are considered as minimum.

5.7.2.2 Blind ends

Branches of the device carrying no current during the test shall be included in the test piece in the shape of blind ends of 300 mm long. If the length of the branch is less than 300 mm, for example for low voltage installations, the length of the blind end shall be the length given by the manufacturer. In all cases the length of the blind end is left free during the short circuit test but shall be insulated in order to prevent unintentional short-circuit.