IEC 61238-1-2

Edition 1.0 2018-05

INTERNATIONAL STANDARD

Compression and mechanical connectors for power cables –
Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on insulated conductors

IEC 61238-1-2:2018-05(en)

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

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

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC 61238-1-2

Edition 1.0 2018-05

INTERNATIONAL STANDARD

Compression and mechanical connectors for power cables – Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on insulated conductors

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-5646-6

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

COMPRESSION AND MECHANICAL CONNECTORS FOR POWER CABLES –

Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on insulated conductors

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61238-1-2 has been prepared by IEC technical committee 20: Electric cables.

This first edition, together with IEC 61238-1-1 and IEC 61238-1-3, cancels and replaces IEC 61238-1:2003.

This edition includes the following significant technical changes with respect to IEC 61238-1:2003:

a) The scope has been widened to cover connectors for conductors from 10 mm^2 down to 2,5 mm^2 and has been limited to 300 mm^2 for copper conductors and 500 mm^2 for aluminium conductors because test experience and applications for IPC are rare for conductors of larger cross-sectional areas.

b) A new mechanical class has been introduced to satisfy the demand for connectors subjected to no mechanical force.

c) The electrical test method has been updated in order to take into consideration the temperature of the insulated reference conductors.

d) For the short-circuit test, the method of calculation and requirements have been updated.

e) For the mechanical test, the methods and requirements have been updated.

f) Different test proposals for multicore connector testing have been introduced.

g) A test proposal for pre-conditioning using live load pickup for insulation piercing connectors has been introduced.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
20/1789/FDIS	20/1804/RVD

Full information on the voting for the approval of this International 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.

A list of all parts in the IEC 61238 series, published under the general title *Compression and mechanical connectors for power cables*, can be found on the IEC website.

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

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

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The IEC 61238 series has been divided into the following parts:

Part 1-1: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on non-insulated conductors

Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on insulated conductors

Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) tested on non-insulated conductors

This Part 1-2 of IEC 61238-1 deals with type tests for insulation piercing connectors for use on copper or aluminium conductors of power cables for rated voltages up to 1 kV (U_m = 1,2 kV).

When a design of connector meets the requirements of this document, then it is expected that in service:

a) the resistance of the connection will remain stable within specified limits;

b) the temperature of the connector will be of the same order or less than that of the insulated conductor during current heating;

c) if the intended use demands it, application of short-circuit currents will not affect a) and b);

d) independently from the electrical performance, conforming axial tensile strength will ensure an acceptable mechanical performance for the connections to the cable conductors, when applicable.

It should be stressed that, although the object of the electrical and mechanical tests specified in this document is to prove the suitability of connectors for most operating conditions, they do not necessarily apply to situations where a connector may be raised to a high temperature by virtue of connection to a highly rated plant, to corrosive conditions, where the connector is subjected to external mechanical stresses such as excessive vibration, shock and large displacement after installation, where the connector is exposed to low temperature during assembly or where the connector is installed in live conditions. In these instances, the tests in this document may need to be supplemented by special tests agreed between supplier and purchaser.

This document does not invalidate existing approvals of products achieved on the basis of national standards and specifications and/or the demonstration of satisfactory service performance. However, products approved according to such national standards or specifications cannot directly claim approval to this document.

Once successfully completed, these tests are not repeated unless changes are made in material, manufacturing process and design which might adversely change the connector performance characteristics.

COMPRESSION AND MECHANICAL CONNECTORS FOR POWER CABLES –

Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on insulated conductors

1 Scope

This part of IEC 61238 applies to insulation piercing connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV), for example according to IEC 60502-1 or other buried cables and cables installed in buildings, having

a) conductors complying with IEC 60228 having nominal cross-sectional areas between 2,5 mm^2 and 300 mm^2 for copper and between 16 mm^2 and 500 mm^2 for aluminium,

b) a maximum continuous cable temperature not exceeding the insulation material properties.

This document is not applicable to connectors for overhead line conductors nor to connectors with a sliding contact.

The object of this document is to define the type test methods and requirements, which apply to insulation piercing connectors for power cables with copper or aluminium conductors. The reference method is to perform the tests on unused insulated conductors.

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 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables* (available at http://www.electropedia.org)

IEC 60228, *Conductors of insulated cables*

IEC 60493-1, *Guide for the statistical analysis of ageing test data – Part 1: Methods based on mean values of normally distributed test results*

IEC 60949:1988, *Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects*
IEC 60949:1988/AMD1:2008

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-461 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
connector
<of cables> device for connecting a conductor to an equipment terminal or for connecting two or more conductors to each other

[SOURCE: IEC 60050-461:2008, 461-17-03, modified – the definition has been revised.]

3.2
through connector
device for connecting two consecutive lengths of conductor together

[SOURCE: IEC 60050-461:2008, 461-17-04, modified – the term "joint ferrule" has been deleted and the definition revised.]

3.3
branch connector
device for connecting a branch conductor to a main conductor at an intermediate point on the latter

[SOURCE: IEC 60050-461:2008, 461-17-05, modified – the term "branch ferrule" has been deleted and in the definition "metallic" has been deleted.]

3.4
reference conductor
length of unjointed insulated conductor or conductor with the insulation rebuilt, which is included in the test loop and which enables the reference temperature and reference resistance to be determined

3.5
equalizer
arrangement used in the test loop to ensure a point of equipotential and uniform current distribution in a stranded conductor

3.6
compression jointing
method of securing a connector to a conductor by using a special tool to produce permanent deformation of the connector and the conductor

3.7
mechanical jointing
method of securing a connector to a conductor, for example by means of a bolt or screw acting on the latter or by alternative methods

3.8
median connector
connector which during the first heat cycle records the third highest temperature of the six connectors in the test loop

3.9
insulation piercing connector
IPC
connector in which electrical contact with the conductor is made by metallic protrusions which pierce the insulation of the cable core

[SOURCE: IEC 60050-461:2008, 461-11-08]

3.10
insulation piercing jointing
method of securing an IPC to an insulated conductor by piercing, boring through, cutting through, or making ineffective in some other manner the insulation of at least one cable conductor without previous stripping during installation

Note 1 to entry: The temperatures are no longer limited by the conductor but by the cable insulation.

Note 2 to entry: This method may allow live line working if the connector provides sufficient insulation properties. Safety requirements for live working are not covered by this document.

3.11
conductor
<of a cable> part of a cable which has the specific function of carrying current

[SOURCE: IEC 60050-461:2008, 461-01-01]

3.12
family of connectors
group of connectors of a manufacturer to be considered of the same design criteria, the same material characteristic and the same installation procedure

4 Symbols

A	nominal cross-sectional area of the conductor
D	change in the resistance factor of the connector
I	direct current flowing through a connection during resistance measurement
I_{RMS}	equivalent RMS short-circuit current
I_N	alternating current necessary to maintain the insulated reference conductor at its equilibrium temperature
I_r	direct current flowing through the insulated reference conductor/conductors during resistance measurement
k	connector resistance factor: ratio of the resistance of a connector to that of the resistance of the equivalent length of the reference conductor
k_0	initial connector resistance factor: ratio of the resistance of a connector to that of the resistance of the equivalent length of the reference conductor at cycle no. 0
l_a, l_b, l_j	lengths of each connector assembly associated with the measurement positions in the test setup after installation
l_r	length of the insulated reference conductor between measurement positions
R	measured resistance value of connector/insulated conductor installation under an electrical test corrected to 20 °C
R_r	measured resistance value of the insulated reference conductor corrected to 20 °C
R_j	length related calculated resistance value of a connector under an electrical test corrected to 20 °C
t_1	heating time
t_2	time necessary for the connectors and the insulated reference conductor to cool to a value equal to or less than 35 °C
U	potential difference between measurement positions while current I is applied
U_r	potential difference between measurement positions on an insulated reference conductor while current I_r is applied
α	temperature coefficient of resistance at 20 °C

β mean scatter of the connector resistance factors

δ initial scatter of the connector resistance factors

λ resistance factor ratio: the actual resistance factor of the connector at each measurement stage divided by its initial resistance factor

θ temperature of a connector

θ_{max} maximum temperature recorded on a connector over the total period of test during heat cycling

θ_R temperature of the main insulated reference conductor determined in the first heat cycle

θ_{Rb} temperature of the branch insulated reference conductor determined in the first heat cycle

θ_{ref} temperature of the related insulated reference conductor at the moment of measuring θ_{max}

5 General

5.1 Definition of classes

Although it is not possible to define precisely the service conditions for all applications, the following requirements have been identified.

a) Electrical requirements:

Class A

These are connectors intended for electricity distribution or industrial networks in which they can be subjected to short-circuits of relatively high intensity and duration. As a consequence, Class A connectors are suitable for the majority of applications.

Class B

These are connectors for networks in which overloads or short-circuits are rapidly cleared by the installed protective devices, for example, fast-acting fuses.

b) Mechanical requirements:

Class 0

Connectors subjected to practically no mechanical pull-out force. These are, for example, connectors inside switchgear where the cable or conductors are secured or anchored.

Class 1

Connectors subjected to a mechanical pull-out force related to the conductor nominal cross-sectional area and material (according to Table 4). These are, for example, connectors for underground cable joints.

Hence, the four classes correspond to the following tests:

Class A: heat cycling and short-circuit tests;

Class B: heat cycling test only;

Class 0: no mechanical test;

Class 1: mechanical test.

5.2 Cable

The following information shall be recorded in the test report:

– conductor material;

– nominal cross-sectional area, dimensions and shape;

– detail of conductor construction shall be given when known, or can be determined by inspection, for example:
  - class according to IEC 60228 (solid, stranded and flexible);
  - compacted or non-compacted for stranded conductor;
  - number and arrangement of strands;
  - type of plating, if applicable;
  - type of impregnation, water blocking, etc., if applicable;
– cable specification, including insulation type and thickness, etc.;
– conditioning of the cable if applied prior to testing.

5.3 Connectors and installation procedure

The following information shall be recorded in the test report:

– the assembly method or the installation instruction that is to be used;
– tooling and any necessary setting;
– identification of the connector, for example name of the supplier, drawing, reference number, type;
– installation temperature and, if applicable, other treatment during installation, for example live load pickup (see Annex I).

5.4 Range of approval

In general, tests made on one type of insulation piercing connector, conductor and insulation combination apply to that arrangement only. However, to limit the number of tests the following is permitted:

– a connector which can be used on stranded round conductors is approved for this type if satisfactory results are obtained on a compacted round conductor;
– a connector which covers a range of consecutive cross-sectional areas shall be approved, if satisfactory results are obtained on the smallest and the largest cross-sectional area;
– if a manufacturer can clearly demonstrate that common and relevant connector design criteria were used for a family of connectors, conformity to this document is achieved by successfully testing the largest, the smallest and two intermediate connector sizes;

  exception no.1: for a family of connectors consisting of five sizes, only the largest connector, the smallest connector, and one connector of a representative intermediate size need to be tested;

  exception no.2: for a family of connectors consisting of four sizes or less, only the largest connector and the smallest connector need to be tested;
– for connectors where one or both sides are designed for a range of cross-sectional areas, and a common clamping or crimping arrangement serves for the connection of the different cross-sectional areas, then mechanical tests on conductors with the largest and smallest cross-sectional areas shall be carried out according to Clause 7 for connectors according to Class 1;
– if conformity to this document is achieved by successfully testing a mechanical connector on round stranded aluminium conductors, this type test approval can be applied to solid aluminium conductors of the same cross-sectional area(s);
– if conformity to this document is achieved by successfully testing a connector on a conductor with water blocking, approval is achieved for the same conductor without any water blocking but not for the same conductor with different types of water blocking.