

# INTERNATIONAL STANDARD

**Compression and mechanical connectors for power cables –  
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**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](http://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](http://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](mailto:sales@iec.ch).

# INTERNATIONAL STANDARD

**Compression and mechanical connectors for power cables –  
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**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-5645-9

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms and definitions .....	7
4 Symbols .....	9
5 General .....	10
5.1 Definition of classes.....	10
5.2 Conductor.....	11
5.3 Connectors and installation procedure .....	11
5.4 Range of approval.....	11
6 Electrical tests .....	12
6.1 Installation .....	12
6.1.1 General .....	12
6.1.2 Through connectors and terminations .....	13
6.1.3 Branch connectors.....	13
6.2 Measurements .....	13
6.2.1 General .....	13
6.2.2 Electrical resistance measurements.....	14
6.2.3 Temperature measurements .....	14
6.3 Heat cycling test .....	14
6.3.1 General .....	14
6.3.2 First heat cycle .....	15
6.3.3 Second heat cycle .....	15
6.3.4 Subsequent heat cycles.....	17
6.4 Short-circuit test for connectors according to Class A .....	17
6.4.1 General .....	17
6.4.2 Aluminium conductors with cross-sectional areas below 1 000 mm <sup>2</sup> and copper conductors with cross-sectional areas below 630 mm <sup>2</sup> .....	18
6.4.3 Aluminium conductors with cross-sectional areas ≥ 1 000 mm <sup>2</sup> and copper conductors with cross-sectional areas ≥ 630 mm <sup>2</sup> .....	18
6.5 Assessment of results .....	19
6.6 Requirements .....	19
6.7 Examples of electrical test loop configurations and associated parameters .....	19
7 Mechanical test .....	25
7.1 General.....	25
7.2 Method .....	25
7.3 Requirements .....	25
8 Test reports .....	26
8.1 General.....	26
8.2 Electrical tests .....	26
8.3 Mechanical test.....	26
Annex A (normative) Equalizers and their preparation.....	27
A.1 Requirements for equalizers .....	27
A.2 Recommendations for welding equalizers .....	27
Annex B (normative) Measurements .....	29

B.1	Potential measuring positions for typical connectors .....	29
B.2	Temperature measurement .....	29
B.3	Equivalent conductor resistance .....	29
Annex C (informative)	Recommendations to decrease uncertainties of measurement .....	30
C.1	Handling the test loop .....	30
C.2	Measurements, instruments and readings .....	30
Annex D (normative)	Calculation of adiabatic short-circuit current.....	31
Annex E (informative)	Determination of the value of the short-circuit current.....	32
Annex F (normative)	Calculation method.....	33
F.1	General.....	33
F.2	Measurements made.....	33
F.3	Connector resistance factor $k$ .....	33
F.4	Initial scatter $\delta$ .....	34
F.5	Mean scatter $\beta$ .....	34
F.6	Change in resistance factor of each connector.....	36
F.6.1	General .....	36
F.6.2	Line of best fit.....	36
F.6.3	Confidence interval $\delta_i$ .....	36
F.6.4	Change in resistance factor $D$ .....	37
F.7	Resistance factor ratio $\lambda$ .....	37
F.8	Maximum temperatures $\theta_{\max}$ .....	37
Annex G (informative)	Explanation on assessment of results of electrical tests on connectors .....	38
G.1	History .....	38
G.2	Short examination of the assessment methods of IEC 61238-1 compared with the Italian standard CEI 20-28 and the British standard BS 4579-3 .....	38
G.3	The IEC 61238-1 method of assessing test results.....	39
Bibliography	.....	41
Figure 1	– Example of second heat cycle profile .....	17
Figure 2	– Typical electrical test loops for through connectors and terminal lugs.....	21
Figure 3	– Typical electrical test loop for branch connectors .....	22
Figure 4	– Typical cases of resistance measurements .....	24
Figure A.1	– Preparation of equalizers .....	28
Figure E.1	– Determination of equivalent RMS value of current during the short-circuit test ..	32
Figure F.1	– Graphic example of assessment of a Class A individual connector.....	35
Table 1	– Minimum period of temperature stability .....	15
Table 2	– Electrical resistance measurements during the electrical test .....	17
Table 3	– Electrical test requirements .....	19
Table 4	– Selection of tensile force withstand values for the mechanical test .....	25
Table D.1	– Material properties .....	31
Table G.1	– Summary of assessed behaviour of a tested connector.....	40

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**COMPRESSION AND MECHANICAL  
CONNECTORS FOR POWER CABLES –****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**

## 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 61238-1-1 has been prepared by IEC technical committee 20: Electric cables.

This first edition, together with IEC 61238-1-2 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 copper conductors from 10 mm<sup>2</sup> down to 2,5 mm<sup>2</sup> and has been limited to 1 200 mm<sup>2</sup> for connectors for copper and aluminium conductors because test experience and applications are rare for conductors of larger cross-sectional areas.

- b) Two new mechanical classes have been introduced to satisfy the demand for connectors subjected to no mechanical force and for connectors subjected to higher mechanical forces than those specified in Class 1 for conductors of larger cross-sectional areas.
- c) For the electrical test, a maximum elevated heating current has been set in order to avoid unrealistic current densities during testing which may change properties of tested connectors.
- 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.

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

FDIS	Report on voting
20/1788/FDIS	20/1803/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 1-1 of IEC 61238 deals with type tests for compression and mechanical 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 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, or where the connector is subjected to external mechanical stresses such as excessive vibration, shock and large displacement after installation. 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 1-1: 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

#### 1 Scope

This part of IEC 61238 applies to compression and mechanical connectors for power cables for rated voltages up to 1 kV ( $U_m = 1,2$  kV), for example buried cables or cables installed in buildings, having

- a) conductors complying with IEC 60228 having nominal cross-sectional areas between 2,5 mm<sup>2</sup> and 1 200 mm<sup>2</sup> for copper and between 16 mm<sup>2</sup> and 1 200 mm<sup>2</sup> for aluminium;
- b) a maximum continuous conductor temperature not exceeding 90 °C.

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 compression and mechanical connectors for power cables with copper or aluminium conductors. The reference method is to perform the tests on unused 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: