

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**



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
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 It also gives information on projects, replaced and withdrawn publications.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.

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

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

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	8
4 Symbols.....	10
5 General.....	11
5.1 Definition of classes.....	11
5.2 Cable.....	11
5.3 Connectors and installation procedure	12
5.4 Range of approval.....	12
6 Electrical tests.....	13
6.1 Installation	13
6.1.1 General	13
6.1.2 Through connectors.....	13
6.1.3 Branch connectors.....	14
6.2 Measurements	14
6.2.1 General	14
6.2.2 Electrical resistance measurements.....	14
6.2.3 Temperature measurements	15
6.3 Heat cycling test	16
6.3.1 General	16
6.3.2 First heat cycle	16
6.3.3 Second heat cycle	16
6.3.4 Subsequent heat cycles.....	18
6.4 Short-circuit test for connectors according to Class A	18
6.5 Assessment of results.....	19
6.6 Requirements	19
6.7 Examples of electrical test loop configurations and associated parameters	20
7 Mechanical test	24
7.1 General.....	24
7.2 Method	24
7.3 Requirements	24
8 Test reports.....	24
8.1 General.....	24
8.2 Electrical tests	24
8.3 Mechanical test.....	25
Annex A (normative) Equalizers and their preparation.....	26
A.1 Requirements for equalizers	26
A.2 Recommendations for welding equalizers	26
Annex B (normative) Measurements	28
B.1 Potential measuring positions for typical connectors	28
B.2 Temperature measurement	28
B.3 Equivalent conductor resistance	28
Annex C (informative) Recommendations to decrease uncertainties of measurement	29
C.1 Handling the test loop	29

C.2	Measurements, instruments and readings	29
Annex D (normative)	Calculation of adiabatic short-circuit current.....	30
Annex E (informative)	Determination of the value of the short-circuit current.....	31
Annex F (normative)	Calculation method.....	32
F.1	General.....	32
F.2	Measurements made.....	32
F.3	Connector resistance factor k	32
F.4	Initial scatter δ	33
F.5	Mean scatter β	33
F.6	Change in resistance factor of each connector.....	35
F.6.1	General	35
F.6.2	Line of best fit.....	35
F.6.3	Confidence interval δ_i	35
F.6.4	Change in resistance factor D	36
F.7	Resistance factor ratio λ	36
F.8	Maximum temperatures θ_{\max}	36
Annex G (informative)	Explanation on assessment of results of electrical tests on connectors.....	37
G.1	History	37
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	37
G.3	The IEC 61238-1 method of assessing test results.....	38
Annex H (informative)	Tests on multicore connectors.....	40
H.1	Principle	40
H.1.1	Electrical tests	40
H.1.2	Mechanical tests.....	40
H.2	Test recommendations for electrical tests based on test experience in the UK and in France	40
H.2.1	General	40
H.2.2	Measurement.....	41
H.2.3	Heat cycling test.....	41
H.2.4	Short-circuit test (only for Class A)	41
H.2.5	Results evaluation	42
H.3	Test recommendations for electrical tests based on German standard DIN VDE 0220- 3	43
H.3.1	General	43
H.3.2	Test setup for electrical test.....	44
H.3.3	Resistance assessment branches of the test setup	45
H.3.4	Temperature measurement in a separate test branch during the first and second heat-cycle	45
H.3.5	Interconnection of terminals for heat-cycling	47
H.3.6	Short-circuit tests	49
H.3.7	Assessment of resistance-values R_j	51
H.3.8	Optional dielectric strength test after the electrical test.....	52
Annex I (informative)	Load pick-up tests	54
Bibliography	55
Figure 1	– Position of thermocouples	15
Figure 2	– Example of second heat cycle profile	17

Figure 3 – Typical electrical test loop for through connectors installed on insulated conductors	21
Figure 4 – Typical electrical test loop for branch connectors installed on insulated conductors	22
Figure 5 – Typical cases of resistance measurements	23
Figure A.1 – Preparation of equalizers	27
Figure E.1 – Determination of equivalent RMS value of current during the short-circuit test ..	31
Figure F.1 – Graphic example of assessment of a Class A individual connector	34
Figure H.1 – Test loops for through connectors	42
Figure H.2 – Test loops for branch connectors	43
Figure H.3 – Example of test setup for multicore branch connectors on a four-core cable consisting of several test branches	45
Figure H.4 – Example of circuit schematic for heat-cycling of multicore branch connectors main to branch, e.g. 150/150, 150/120 or 150/95 in the case of four-core cables	48
Figure H.5 – Example of circuit schematic for heat-cycling of multicore branch connectors main to branch, e.g. 150/70 and smaller in the case of four-core cables	49
Figure H.6 – Example of circuit schematic in the case of four-core cable connector tests for passing short circuits on main through adjacent Phases L2–L3 with opposite current flow	50
Figure H.7 – Example of circuit schematic in the case of four-core cable branch connector tests for short circuit test from main to branch through adjacent Phases L4–L1 with opposite current flow	51
Table 1 – Minimum period of temperature stability	16
Table 2 – Electrical resistance measurements during the electrical test	18
Table 3 –Electrical test requirements	20
Table 4 – Selection of tensile force withstand values for the mechanical test	24
Table D.1 – Material properties	30
Table G.1 – Summary of assessed behaviour of a tested connector	39
Table I.1 – Minimum load pick-up	54

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 mm² down to 2,5 mm² and has been limited to 300 mm² for copper conductors and 500 mm² 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 mm² and 300 mm² for copper and between 16 mm² and 500 mm² 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: