



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 ² and copper conductors with cross-sectional areas below 630 mm ²	18
6.4.3 Aluminium conductors with cross-sectional areas ≥ 1 000 mm ² and copper conductors with cross-sectional areas ≥ 630 mm ²	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 δ	34
F.5	Mean scatter β	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 δ_i	36
F.6.4	Change in resistance factor D	37
F.7	Resistance factor ratio λ	37
F.8	Maximum temperatures θ_{\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 mm² down to 2,5 mm² and has been limited to 1 200 mm² 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 mm² and 1 200 mm² for copper and between 16 mm² and 1 200 mm² 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