IEC 61238-1-3

Edition 1.0 2018-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Raccords sertis et à serrage mécanique pour câbles d'énergie –
Partie 1-3: Méthodes et exigences d'essai relatives aux raccords sertis et à serrage mécanique pour câbles d'énergie de tensions assignées supérieures à 1 kV (U_m = 1,2 kV) jusqu'à 30 kV (U_m = 36 kV) soumis à essai sur des conducteurs non isolés**

IEC 61238-1-3:2018-05(en-fr)

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Raccords sertis et à serrage mécanique pour câbles d'énergie – Partie 1-3: Méthodes et exigences d'essai relatives aux raccords sertis et à serrage mécanique pour câbles d'énergie de tensions assignées supérieures à 1 kV (U_m = 1,2 kV) jusqu'à 30 kV (U_m = 36 kV) soumis à essai sur des conducteurs non isolés

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COMPRESSION AND MECHANICAL CONNECTORS FOR POWER CABLES –

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

FOREWORD

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International Standard IEC 61238-1-3 has been prepared by IEC technical committee 20: Electric cables.

This first edition, together with IEC 61238-1-1 and IEC 61238-1-2, 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 1 200 mm^2 for connectors for copper and aluminium conductors because test experience and applications 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 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 the test which may change the 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.

f) A proposal for an electrical test on cable terminal lugs for application in separable connectors has been introduced.

This bilingual version (2018-11) corresponds to the monolingual English version, published in 2018-05.

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

FDIS	Report on voting
20/1790/FDIS	20/1805/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.

The French version of this standard has not been voted upon.

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.

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 1-3 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 above 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 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.

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 1-3: 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

1 Scope

This part of IEC 61238 applies to 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), 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^2 and 1 200 mm^2 for copper and between 16 mm^2 and 1 200 mm^2 for aluminium, excluding Milliken conductors;

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:

- 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
termination
device fitted to the end of a cable conductor to ensure electrical connection with other parts of the system

[SOURCE: IEC 60050-461:2008, 461-10-01, modified – "conductor" has been added and "and to maintain insulation up to the point of connection" has been deleted.]

3.5
terminal lug
device to connect a cable conductor to other electrical equipment

[SOURCE: IEC 60050-461:2008, 461-17-01, modified – "metallic" has been deleted.]

3.6
palm
<of terminal lug> part of a terminal lug used to make the connection to electrical equipment

[SOURCE: IEC 60050-461:2008, 461-17-07]

3.7
barrel
<of terminal lug, of connector> part of a device into which the conductor to be connected is introduced

[SOURCE: IEC 60050-461:2008, 461-17-06]

3.8
reference conductor
length of unjointed bare conductor or conductor with the insulation removed, which is included in the test loop and which enables the reference temperature and reference resistance to be determined

3.9
equalizer
arrangement used in the test loop to ensure a point of equipotential and uniform current distribution in a stranded conductor

3.10
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

3.11
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

3.12
median connector
connector which during the first heat cycle records the third highest temperature of the six connectors in the test loop

3.13
conductor
<of a cable> part of a cable which has the specific function of carrying current

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

3.14
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 reference conductor at its equilibrium temperature
I_{r}	direct current flowing through the 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 set-up after installation
l_{r}	length of the reference conductor between measurement positions
R	measured resistance value of connector/conductor installation under an electrical test corrected to 20 °C
R_{r}	measured resistance value of the 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 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 a 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 reference conductor determined in the first heat cycle
θ_{ref}	temperature of the related 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

Connectors related to this document are intended for electricity distribution or industrial networks in which they can be subjected to short-circuits of relatively high intensity and duration.

b) Mechanical requirements:

Class 1

Connectors subjected to a mechanical pull-out force related to the conductor nominal cross-sectional area and material (according to Table 4) but limited to 20 kN pull-out force. These are, for example, connectors for underground cable joints.

Class 2

Connectors subjected to a mechanical pull-out force above 20 kN and related to the conductor nominal cross-sectional area and material (according to Table 4). This class is only applicable to conductor nominal cross-sectional areas ≥ 400 mm^2 copper and ≥ 630 mm^2 aluminium. These are, for example, connectors in cable installations where thermomechanical forces are estimated to exceed 20 kN.

Hence, the three classes correspond to the following tests:

Class A: heat cycling and short-circuit tests;

Class 1: mechanical test with limited maximum tensile force;

Class 2: mechanical test with no maximum tensile force.

5.2 Conductor

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.

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, dies and any necessary setting;
– if not part of the delivered product, for example at cable conductor termination: bolts, nuts, washers, lubricant, torque, etc.;
– preparation of contact surfaces, if applicable, for example cleaning, brushing and/or greasing of inner and/or outer conductor and/or connector surfaces;
– identification of the connector, for example name of the supplier, drawing, reference number, type.

5.4 Range of approval

In general, tests made on one type of connector/conductor combination apply to that arrangement only. However, to limit the number of tests using the same conductor material, the following is permitted:

– a connector which can be used on stranded round conductors or on stranded sector-shaped conductors which have been rounded, is approved for both types 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 connector is a through connector for two conductors of different cross-sectional areas, shapes, or materials, and if the jointing method and the connector barrels used have already been tested separately for each cross-sectional area, no additional test is necessary. If not, and if it is required for bimetallic through connectors, additional tests shall be made using the conductor having the highest temperature of the two conductors, as reference conductor;
– if a type test for a range taking mechanical connector is passed on the biggest possible conductor cross-sectional area, this result is also valid for similar connector designs with the same material of the connector body but bigger outer diameter provided that the design of the conductor clamping channel (inner diameter, shape, etc.), quantity and design of clamping screws (torque, material, size, shear-off characteristic, etc.) are identical;
– 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;

- if conformity to this document is achieved by successfully testing a connector on dry conductor then approval is achieved for the same conductor used in an impregnated paper insulated cable;
- 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;
- 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 successful testing of a through connector, this type test approval can apply to the barrel of a termination which uses the same design criteria. Approval of the complete termination can be achieved if the termination connection does not influence the barrel performance, proven through design parameters, drawings or through thermal verification test;
- 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.

6 Electrical tests

6.1 Installation

6.1.1 General

All conductors of the same cross-sectional area in the test loop shall be taken from the same conductor length.

For each series of tests, six connectors shall be installed in accordance with the manufacturer's instructions, on a bare conductor or on a conductor that has had the insulation removed before assembly, to form a test loop together with the corresponding reference conductor.

For stranded conductors, potential differences between the strands at potential measuring positions can cause errors in measuring electrical resistance. Equalizers according to Annex A shall be used to overcome this problem and to ensure uniform current distribution in the reference conductor and between connectors at the equalizer positions. The recommended method is to prepare equalizers on the test loop before installing connectors.

The test loop shall be installed in a location where the air is calm.

The ambient temperature of the test location shall be between 15 °C and 30 °C.

For conductor cross-sectional areas above 1 000 mm^2, increasing the ambient temperature range of the test location between 15 °C and 40 °C is allowed. At the end of the cooling phase the ambient temperature shall be between 15 °C and 30 °C.

In the case of solid conductors, the potential measuring positions shall be as close as possible to the connector in order to reduce l_a and l_b close to zero.

The test loop may be of any shape according to Figures 2 or 3 provided that it is arranged in such a way that there is no adverse effect from the floor, walls and ceiling, other test loops and adjacent test branches.

To facilitate the short-circuit test, the loop may be disassembled as shown in Figure 2 b). In this case, the sectioning connections shall not influence the temperatures of the test objects during heating.