



BSI Standards Publication

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)

National foreword

This British Standard is the UK implementation of EN IEC 61238-1-2:2019 . It is identical to IEC 61238-1-2:2018. Together with BS EN IEC 61238-1-1:2019 and BS EN IEC 61238-1-3:2019+A11:2019, it supersedes BS EN 61238-1:2003, which will be withdrawn on 19 July 2022.

The UK participation in its preparation was entrusted to Technical Committee GEL/20/11, Electric Cable accessories.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

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)

Raccords sertis et à serrage mécanique pour câbles
d'énergie - Partie 1-2: Méthodes et exigences d'essai
relatives aux raccords à perforation d'isolant pour câbles
d'énergie de tensions assignées inférieures ou égales à
1kV ($U_m = 1,2$ kV) soumis à essai sur des conducteurs isolés
(IEC 61238-1-2:2018)

Pressverbinder und Schraubverbinder für Starkstromkabel -
Teil 1-2: Prüfverfahren für und Anforderungen an
isolationsdurchdringende Verbinder für Starkstromkabel für
Nennspannungen bis zu 1 kV ($U_m = 1,2$ kV), geprüft an
isolierten Leitern
(IEC 61238-1-2:2018)

This European Standard was approved by CENELEC on 2019-07-19. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN IEC 61238-1-2:2019) consists of the text of IEC 61238-1-2:2018 prepared by IEC/TC 20 "Electric cables".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-07-19
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2022-07-19

This document partially supersedes EN 61238-1:2003 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61238-1-2:2018 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61238-1	NOTE Harmonized as EN 61238-1.
IEC 61238-1-1	NOTE Harmonized as EN IEC 61238-1-1.
IEC 61238-1-3	NOTE Harmonized as EN IEC 61238-1-3.
IEC 62475:2010	NOTE Harmonized as EN 62475:2010 (not modified).

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-461	-	International Electrotechnical Vocabulary - Part 461: Electric cables	-	-
IEC 60228	-	Conductors of insulated cables	EN 60228	-
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	-	-
+ A1	2008		-	-

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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.
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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.

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

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.

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 1-2 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:

- 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
$l_{\text{a}}, l_{\text{b}}, l_{\text{j}}$	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
$\theta_{\max}$	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 $\theta_{\max}$

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.

6 Electrical tests

6.1 Installation

6.1.1 General

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

For each series of tests, six connectors shall be installed on insulated conductors in accordance with the manufacturer's instructions.

At a distance not less than 100 mm to the entrance of the connector, the insulation can be removed to prepare equalizers according to Annex A.

Reference conductor(s) with the insulation retained shall also be included in the test loop.

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 assembly of the test objects, the temperature shall be (23 ± 3) °C. The test objects should be stored for a sufficient time to reach the required installation temperature.

In the case of solid conductors, the potential measuring positions shall be as close as possible to the connector in order to reduce I_a and I_b . A minimum distance of 10 mm shall be kept to the cable entrance of the IPC to avoid any influence on the IPC by cutting through the cable insulation when setting the measuring position.

The test loop may be of any shape according to Figure 3 or Figure 4 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 for connectors according to Class A, the loop may be disassembled as shown in Figure 3 b). In this case, the sectioning connections shall not influence the temperatures of the test objects during heating.

Retightening of bolts or screws of the connectors under test is not permitted.

NOTE 1 Informative Annex H proposes electrical tests for multicore connectors. These tests are not internationally recognized and subject to customer/manufacture agreement.

NOTE 2 Informative Annex I gives recommendations to simulate loads (related to the cross sectional area) acting during installation of an IPC while the cables are still in service. This test is done during the initial insertion of the IPC in the test loop, before starting electric tests.

6.1.2 Through connectors

The test loop shown in Figure 3 indicates the dimensions that shall be used.

6.1.3 Branch connectors

When the branch connector is intended for a branch nominal cross-sectional area equal to the main, or a nominal cross-sectional area immediately above or below the main, it is treated as a through connector between the main and the branch, and the test method for through connectors and the test loop shown in Figure 3 c) are applicable. In other cases, the test loop shall be as shown in Figure 4. Where a type of connector makes it necessary for the insulated main conductor to be cut, that part of the connector which acts as a through connector, shall also be tested as for through connectors.

6.2 Measurements

6.2.1 General

Measurements shall be made at stages throughout the test according to Table 2.

NOTE Recommendations to decrease uncertainties of measurements are given in Annex C.

6.2.2 Electrical resistance measurements

The resistance measurements shall be made under steady temperature conditions of both the test loop and test location. The ambient temperature shall be between 15 °C and 30 °C.

The recommended method is to pass a direct current of up to 10 % of the estimated heat cycling current, through the connectors and the insulated reference conductor, without significantly increasing the temperature and to measure the potential difference between two specific potential measuring positions. The ratio of potential difference and direct current is the resistance between those two positions.

To decrease the uncertainty of the resistance measurement, it is recommended that the direct current is adjusted to the same value throughout the electrical test.

For insulated branch conductors assembled in accordance with Figure 4, the whole of the measuring current shall flow through that part of the connector whose potential difference is being measured. Switches or disconnecting terminals may be provided for this purpose.

Thermoelectric voltages may affect the uncertainty of low resistance measurements (of the order of 10 $\mu\Omega$). If this is suspected, the recommended method is to take two resistance measurements with the direct measuring current reversed between readings. The mean of the two readings is then the actual resistance of the sample.

The potential measuring positions shall be as indicated in Figure 5 and Annex B. The various lengths shall also be measured individually to enable the actual connector resistances to be determined. The temperature of connector and insulated reference conductor shall be recorded when resistance measurements are made. For direct comparison, the resistance values shall be corrected to 20 °C. Information on the recommended method is also given in Annex B. Temperature measurements at these positions shall be made during the heat cycling test.

Indirect resistance readings:

- voltage measurements shall have a device uncertainty within $\pm 0,5$ % or ± 10 μV , by taking the greater value;
- current measurements shall have a device uncertainty within $\pm 0,5$ % or $\pm 0,1$ A, by taking the greater value.

Direct resistance readings: