

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**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**

[IEC 61238-1-1:2018](#)

<https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7->

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



## 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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).

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Catalogue IEC - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

#### Recherche de publications IEC - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 21 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**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**

[IEC 61238-1-1:2018](#)

<https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7-8c2388410061/iec-61238-1-1-2018>

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 29.060.20

ISBN 978-2-8322-6150-7

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## 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 $\gamma$ .....	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. [standards.iteh.ai](http://standards.iteh.ai/)
- 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. <http://www.iteh.ai/>
- 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 bilingual version (2018-11) corresponds to the monolingual English version, published in 2018-05.

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.

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

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

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.

<https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7-23681e1c3618/iec-61238-1-1-2018>

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 1-1 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

[IEC 61238-1-1:2018](https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7-fb623fc8b441/iec-61238-1-1-2018)

<https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7-fb623fc8b441/iec-61238-1-1-2018>

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

<https://standards.iteh.ai/catalog/standards/sist/523591be-0c19-41a0-84d7-fb623f8b441/iec-61238-1-1-2018>

[SOURCE: IEC 60050-461:2008, 461-10-01, modified – "conductor" has been added and "and to maintain the 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, etc.> 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
$I_{\text{RMS}}$	equivalent RMS short-circuit current
$I_{\text{N}}$	alternating current necessary to maintain the reference conductor at its equilibrium temperature
$I_{\text{r}}$	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
$l_{\text{a}}, l_{\text{b}}, l_{\text{j}}$	lengths of each connector assembly associated with the measurement positions in the test setup after installation
$l_{\text{r}}$	length of the reference conductor between measurement positions
$R$	measured resistance value of connector/conductor installation under an electrical test corrected to 20 °C
$R_{\text{r}}$	measured resistance value of the reference conductor corrected to 20 °C
$R_{\text{j}}$	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
$\alpha$	temperature coefficient of resistance at 20 °C
$\beta$	mean scatter of the connector resistance factors
$\delta$	initial scatter of the connector resistance factors
$\lambda$	resistance factor ratio: the actual resistance factor of the connector at each measurement stage divided by its initial resistance factor
$\theta$	temperature of a connector
$\theta_{\max}$	maximum temperature recorded on a connector over the total period of test during heat cycling
$\theta_R$	temperature of the reference conductor determined in the first heat cycle
$\theta_{\text{ref}}$	temperature of the related reference conductor at the moment of measuring $\theta_{\max}$

## 5 General

## iTeh STANDARD PREVIEW

### 5.1 Definition of classes

(standards.iteh.ai)

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) but limited to a 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 2 is only applicable to conductor nominal cross-sectional areas  $\geq 400 \text{ mm}^2$  for copper and  $\geq 630 \text{ mm}^2$  for aluminium. These are for example connectors in cable installations where thermomechanical forces are estimated to exceed 20 kN.

Hence, the five 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 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, when 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 areas;
- 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 a 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 for connectors according to Class 1 or Class 2;
- 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 tests;
- 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;
- if conformity to IEC 61238-1-3 is achieved by successfully testing a connector, approval is achieved for the same classes and conductors in this document.

## 6 Electrical tests

### 6.1 Installation

#### 6.1.1 General

All conductors of the same nominal 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<sup>2</sup>, it is allowed to increase the ambient temperature range of the test location between 15 °C and 40 °C. 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  $I_a$  and  $I_b$  close to zero.

The test loop may be of any shape according to Figure 2 or Figure 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 for connectors according to Class A, 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.

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

### 6.1.2 Through connectors and terminations

The test loop shown in Figure 2 indicates the dimensions that shall be used.

Where terminal lugs or mechanical connectors for terminal bars are to be tested, they shall be bolted to linking bars in accordance with the manufacturer's instructions or other relevant standards/specifications defining methods and instructions for fastening terminations. These linking bars shall, at the point of connection, be of the same dimensions and thickness as the palm, and also of the same material.

It may be necessary to adjust the thermal characteristics of the linking bar outside the point of connection, to achieve the temperatures specified in 6.3.

For terminal lugs, the use of linking bars is the recommended test method although it is alternatively possible to test terminal lugs with palms connected directly to palms.

If it is requested that the terminal lug test includes an evaluation of the performance of the bolted palm when connected to a specified plant terminal, then the linking bar method shall be used and the linking bar ends, or an intermediate piece, shall be defined and described in material, size and surface coating.

### 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 as shown in Figure 2 is applicable. In other cases, the test loop shall be as shown in Figure 3. Where a type of connector makes it necessary for the 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.