

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Solderless connections –

Part 2: Crimped connections – General requirements, test methods and practical guidance

Connexions sans soudure –

Partie 2: Connexions serties – Exigences générales, méthodes d'essai et guide pratique



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 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 Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications provided, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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.

Recherche de publications IEC -

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

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

Service Clients - 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.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Solderless connections –
Part 2: Crimped connections – General requirements, test methods and
practical guidance**

**Connexions sans soudure –
Partie 2: Connexions serties – Exigences générales, méthodes d'essai et guide
pratique**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.120.20

ISBN 978-2-8322-9903-6

**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.....	10
INTRODUCTION.....	13
1 Scope.....	14
2 Normative references	14
3 Terms and definitions	16
4 Workmanship.....	25
5 Prerequisites for basic test schedule	26
5.1 Classification by end-product class	26
5.1.1 General	26
5.1.2 Class A – General electrical and electronics products.....	26
5.1.3 Class B – Dedicated service electrical and electronics products	26
5.1.4 Class C – High-performance electrical and electronics products	26
5.2 Prerequisites for tools	26
5.3 Prerequisites for crimp barrels	27
5.3.1 Crimp barrel materials	27
5.3.2 Crimp barrel dimensions	27
5.3.3 Crimp barrel surface finishes	27
5.3.4 Crimp barrel design features.....	28
5.4 Prerequisites for wires	28
5.4.1 General	28
5.4.2 Conductor materials.....	28
5.4.3 Conductor dimensions	28
5.4.4 Conductor surface finishes	29
5.4.5 Wire insulation.....	29
5.4.6 Wire cutting and stripping	29
5.5 Prerequisites for crimped connections.....	31
5.5.1 Compatibility of combination	31
5.5.2 Conductor location	31
5.5.3 Crimping location.....	31
5.5.4 Contact deformation	31
5.5.5 Prerequisites for crimped connections with more than one conductor in the crimp barrel	31
5.5.6 Adjustment of conductor cross-sectional area to the crimp barrel.....	32
5.5.7 Crimp contacts and terminal ends.....	32
5.5.8 Splice crimp barrels	36
5.6 Prerequisites for splice crimped connections.....	37
5.6.1 General	37
5.6.2 Conductor requirements for crimped splices	37
6 Testing	38
6.1 General.....	38
6.2 Standard conditions for testing.....	39
6.3 Pre-conditioning.....	39
6.4 Recovery	39
6.5 Mounting of the specimen	39
7 Test methods and test requirements.....	40
7.1 General examination of crimp barrels and wires	40

7.2	Examination of crimp dimensions	40
7.2.1	Crimp height C_h , crimp width C_w and measurable crimp width C_{wm}	40
7.2.2	Contact deformation after crimping	42
7.2.3	Visual examination of insulation distance and conductor overhang	43
7.2.4	Visual examination of splice crimped connections	44
7.2.5	Visual examination of crimped connections on closed (machined) crimp barrels	44
7.2.6	Visual examination of crimped connections on B-crimp open crimp barrels	44
7.2.7	Visual examination of crimped connections with open crimp barrel with insulation grip	44
7.3	Mechanical tests	46
7.3.1	Tensile strength	46
7.3.2	Microsection	48
7.3.3	Insulation grip effectiveness	49
7.3.4	Bending test (uninsulated crimp barrels with insulation grip)	50
7.3.5	Bending test (pre-insulated crimp barrels with insulation grip)	51
7.3.6	Bending test on splice crimped connections	52
7.3.7	Vibration test	52
7.4	Electrical tests	53
7.4.1	Crimp resistance	53
7.4.2	Voltage proof (crimped connection with pre-insulated crimp barrels)	58
7.4.3	Current-carrying capacity test with temperature rise	58
7.5	Climatic tests	60
7.5.1	General	60
7.5.2	Rapid change of temperature	60
7.5.3	Dry heat	61
7.5.4	Climatic sequence	61
7.5.5	Current loading, cycling	62
7.5.6	Crimping at low temperature (crimped connections with pre-insulated crimp barrels)	66
7.6	Miscellaneous tests	67
7.6.1	Fluid resistance of pre-insulated crimp barrels	67
7.6.2	Flowing mixed gas corrosion test	67
8	Test schedules	68
8.1	Preparation and type of test specimens	68
8.1.1	Preparation of test specimens	68
8.1.2	Type A specimen (for testing according to 8.2, 8.2.3.3 if required, 8.3.2, 8.3.4 if required)	68
8.1.3	Type B specimen (for tests according to 8.2.3.1 and 8.3.3.2)	68
8.1.4	Type C specimen (for insulation grip effectiveness tests, see 8.2.3.3 and 8.3.4)	69
8.1.5	Type D specimen (for testing of pre-insulated crimp barrels only, see 8.2.3.4, 8.3.9.2 and 8.3.9.3)	70
8.1.6	Type E specimen (for tests according to 8.2.3.2, 8.2.3.4, 8.3.3.5)	70
8.1.7	Type F specimen (for testing of pre-insulated crimp barrels according to 8.3.9.4)	71
8.1.8	Type G specimen (for testing according to 8.2.3.2, 8.3.3.4, 8.3.3.5 and 8.3.6)	72
8.1.9	Type H specimen (for testing according to 8.2.2, 8.2.3.1, 8.2.3.3, 8.3.2, 8.3.3.2, 8.3.3.3 and 8.3.4)	72

8.1.10	Number of specimens required	73
8.2	Basic test schedule	74
8.2.1	General	74
8.2.2	Initial examination.....	74
8.2.3	Testing of crimped connections	75
8.3	Full test schedule.....	77
8.3.1	General	77
8.3.2	Initial examination.....	78
8.3.3	Testing of crimped connections	78
8.3.4	Testing of insulation grip effectiveness, test group F5.....	80
8.3.5	Testing of stability of splice crimped connections under bending	81
8.3.6	Test group F7, if required	81
8.3.7	Test group F8, if required	81
8.3.8	Test group F9, if required	81
8.3.9	Testing of crimped connections with pre-insulated crimp barrels	82
8.4	Flow charts	83
Annex A	(informative) Practical guidance.....	86
A.1	General information on crimped connections.....	86
A.1.1	General	86
A.1.2	Advantages of crimped connections.....	86
A.1.3	Current-carrying capacity considerations	86
A.2	Tool information.....	87
A.3	Crimp barrel information	88
A.3.1	General	88
A.3.2	Materials	89
A.3.3	Surface finishes.....	89
A.3.4	Shapes of crimped connections.....	89
A.4	Wire information.....	91
A.4.1	General	91
A.4.2	Conductor materials.....	92
A.4.3	Conductor surface finishes	92
A.4.4	Wire stripping information	92
A.5	Crimped connection information.....	95
A.5.1	General	95
A.5.2	Additional information	96
A.5.3	Crimped connections made with more than one wire in a crimp barrel	99
A.5.4	Dimensions after crimping	100
A.5.5	Conductor and crimp barrel materials and finishes selection	100
A.6	Crimping process	100
A.6.1	Crimping of contacts with open crimp barrel	100
A.6.2	Crimping of contacts with open crimp barrel, loose piece contacts.....	100
A.6.3	Processing instruction	101
A.7	Correct crimped connections (additional information).....	102
A.7.1	Correct crimped connections of contacts with open crimp barrel	102
A.7.2	Measuring of crimp height or depth.....	103
A.7.3	Pull-out force.....	104
A.8	Examination by microsection.....	110
A.8.1	Microsection image creation	110
A.8.2	Graphical representation of the microsection image requirements	111

A.8.3	Microsection terminology	112
A.8.4	Porosity ratio of crimped connections in microsections	114
A.8.5	Crimp compression ratio of the crimped connection in the microsection	115
A.8.6	Ratio of crimp height to crimp width in the microsection	115
A.8.7	Requirements for B-crimped connections in the microsection	116
A.8.8	Condition of microsections	117
A.8.9	Insulation grip	119
A.9	Faults with crimped contacts having open crimp barrels	121
A.10	Splices	121
A.11	Crimp resistance test	121
A.11.1	General	121
A.11.2	Notes on specimen preparation and measurement	125
A.12	General information about crimp contacts as part of a multipole connector	125
A.12.1	Insertion of crimped contacts into the contact cavities of the connector insert	125
A.12.2	Removal of inserted contacts	126
A.12.3	Mounting and bending of wire bundles or cables with crimped contacts	126
A.12.4	Mating and unmating of multipole connectors with crimped contacts	127
A.13	Final remarks	127
	Bibliography	128
	Figure 1 – Examples of crimp contact	17
	Figure 2 – Examples of splice	18
	Figure 3 – Example of insulation support	18
	Figure 4 – Examples of insulation grip	19
	Figure 5 – Examples of crimping tool	19
	Figure 6 – Example of positioner holding the crimp barrel	20
	Figure 7 – Example of positioner holding the stripped wire	20
	Figure 8 – Open crimp barrel	22
	Figure 9 – Closed crimp barrels	22
	Figure 10 – Pre-insulated crimp barrel	23
	Figure 11 – Crimping cones	23
	Figure 12 – Example of crimp funnel	24
	Figure 13 – Concentricity of wire insulation	29
	Figure 14 – Diameter ratio when crimping wires with different individual strand diameters	32
	Figure 15 – Examples of open stamped crimp contacts for automatic production	32
	Figure 16 – Stamped open B-crimp contact with anvil and punch shapes	33
	Figure 17 – Designations on open B-crimp contact	33
	Figure 18 – Examples of crimping dies (press dies)	33
	Figure 19 – Stamped closed crimp barrel (crimp cable lug)	34
	Figure 20 – Different crimp shapes	34
	Figure 21 – Examples of crimping dies for closed crimp barrels	34
	Figure 22 – Tubular cable lugs for class 5 conductors	35
	Figure 23 – Tubular cable lugs for class 6 conductors	35
	Figure 24 – Crimping process of 4-indent crimping with adjustable tools	35

Figure 25 – Pre-insulated stamped close crimp barrel, area definitions	36
Figure 26 – Pre-insulated closed crimp barrels of various designs	36
Figure 27 – Examples of pre-insulated crimp cable lugs as strip parts.....	36
Figure 28 – Uninsulated splice variants.....	37
Figure 29 – Diameter ratio when crimping wires with different individual strand diameters in splices	38
Figure 30 – Crimp height measurement on open crimp barrel (B-crimp).....	41
Figure 31 – Crimp height measurement on closed crimp barrel (mandrel crimping).....	41
Figure 32 – Crimp height measurement on closed crimp barrel (4-indent crimping).....	42
Figure 33 – Example of holding and measuring points for contact deformation.....	43
Figure 34 – Insulation distance and conductor overhang.....	43
Figure 35 – Examples of insulation grip die shapes.....	45
Figure 36 – Examples of insulation grip	45
Figure 37 – Test arrangement.....	50
Figure 38 – Bending test of crimped connections with uninsulated crimp barrels.....	50
Figure 39 – Bending test of crimped connections with pre-insulated crimp barrels	51
Figure 40 – Bending test on splice crimped connections	52
Figure 41 – Arrangement for vibration test.....	53
Figure 42 – Test arrangement for measurement of crimp resistance of single-conductor crimped connection.....	54
Figure 43 – Measuring of crimp resistance of splices of multiple-conductor crimp connections	54
Figure 44 – Crimp resistance R_C of crimped connections with copper barrels and copper conductor ($K = 1$)	56
Figure 45 – Test setup for temperature rise measurements under current load	58
Figure 46 – Temperature chamber with ventilation opening for current-temperature derating measurements	60
Figure 47 – Examples of test arrangements	64
Figure 48 – Test current for crimped connections.....	65
Figure 49 – Examples of type A specimens.....	68
Figure 50 – Examples of type B specimens.....	69
Figure 51 – Examples of type C specimens.....	70
Figure 52 – Example of type D specimen (pre-insulated)	70
Figure 53 – Examples of type E specimen.....	71
Figure 54 – Example of type F specimen	72
Figure 55 – Type G specimen (splice).....	72
Figure 56 – Type H specimen (splice).....	73
Figure 57 – Basic test schedule (see 8.2)	84
Figure 58 – Full test schedule (see 8.3)	85
Figure A.1 – Open crimp barrels	88
Figure A.2 – Closed crimp barrels	89
Figure A.3 – Crimping shape in the wire axis	90
Figure A.4 – Crimping shape 90° angled to the wire axis	90
Figure A.5 – Crimping shape without insulation grip.....	90

Figure A.6 – Crimping shape with pre-insulated crimp barrel.....	91
Figure A.7 – Crimping shape without pre-insulated crimp barrel.....	91
Figure A.8 – Crimped connections using solid round conductors.....	92
Figure A.9 – Stripping length	93
Figure A.10 – Example of parallel (in-line) process crimping and angled crimping process.....	101
Figure A.11 – Crimping process of an open crimp barrel (B-crimp).....	102
Figure A.12 – Correct crimped connections of contacts with open crimp barrel	102
Figure A.13 – Measuring instructions	103
Figure A.14 – Crimp height measuring procedure	104
Figure A.15 – Pull-out force test for crimped connections with pull speed 50 mm/min	105
Figure A.16 – Determination of the intrinsic tensile strength of the conductor (50 mm/min)	107
Figure A.17 – Relationships between crimp height (C_H), pull-out force, crimp force (indentation depth), and electrical conductivity.....	109
Figure A.18 – Pull-out force test of splice crimp connections (50 mm/min).....	110
Figure A.19 – Illustration of the parting plane on the crimp barrel centred in the crimping zone (X).....	111
Figure A.20 – Example of end-feed (length feed) open barrel crimp contacts	111
Figure A.21 – Cutting the crimped connection.....	111
Figure A.22 – Dimensions on the microsection for B-crimp barrels.....	112
Figure A.23 – Dimensions on the microsection for nose tube and crimped cable lugs.....	113
Figure A.24 – Dimensions on the microsection for 4-sided closed crimp barrels.....	113
Figure A.25 – Dimensions on the microsection for hexagonal crimp barrels	113
Figure A.26 – Dimensions on the microsection for crimp barrels (also pre-insulated)	114
Figure A.27 – Examples of microsections of crimp barrels	114
Figure A.28 – Ratio of crimp height C_H to crimp width C_W	115
Figure A.29 – Ratio of distance between crimp face ends CFE and base material thickness S	116
Figure A.30 – Support angle α_W of the crimp flanks.....	116
Figure A.31 – Support height L_a of the crimp flanks	116
Figure A.32 – Crimp edge distance to floor (F_a).....	116
Figure A.33 – Resulting bottom thickness S_b after crimping	117
Figure A.34 – Requirements for the acceptance of a burr formation	117
Figure A.35 – Diagrams for resistance values (A and B) for electrolytic copper conductor ($K = 1$) and for material with $K = 3,8$	122
Figure A.36 – Replacement circuit diagram for the crimp resistance	123
Figure A.37 – Insertion of crimped contacts into contact cavities.....	126
Figure A.38 – Mounting of wire bundles/cables with crimped contacts.....	126
Figure A.39 – Bending of wire bundles of connectors.....	127
Figure A.40 – Mating and unmating of multipole connectors.....	127
Table 1 – Allowable strand damage	30
Table 2 – Prerequisites of 5.3 for crimp barrels to access the basic test schedule of 8.2.....	38

Table 3 – Prerequisites of 5.4 for wires to access the basic test schedule of 8.2.....	39
Table 4 – Magnification aids for visual examination	40
Table 5 – Example of permissible tolerances for crimp height measurements	42
Table 6 – Insulation distance and conductor overhang on closed crimp barrels.....	44
Table 7 – Pull-out force of crimped connections.....	47
Table 8 – Vibration, preferred test severities.....	53
Table 9 – Example of other materials.....	57
Table 10 – Minimum wire length L as a function of conductor cross-sectional area S	59
Table 11 – Current values (tentative) – alternative current loading, cyclic method.....	66
Table 12 – Number of specimens.....	73
Table 13 – Test group B0.....	75
Table 14 – Test group B1.....	75
Table 15 – Test group B2.....	76
Table 16 – Test group B3.....	76
Table 17 – Test group B4.....	77
Table 18 – Test group B5.....	77
Table 19 – Test group F0.....	78
Table 20 – Test group F1.....	79
Table 21 – Test group F2.....	79
Table 22 – Test group F3.....	79
Table 23 – Test group F4.....	80
Table 24 – Test group F5.....	80
Table 25 – Test group F6.....	81
Table 26 – Test group F7.....	81
Table 27 – Test group F8.....	81
Table 28 – Test group F9.....	82
Table 29 – Test group F10.....	82
Table 30 – Test group F11.....	83
Table 31 – Test group F12.....	83
Table A.1 – Stripping on stranded conductors (good to sufficient requirements).....	94
Table A.2 – Stripping on stranded conductors (faults or conditions according to Table 1)	95
Table A.3 – Condition of closed machined crimp barrels	97
Table A.4 – Condition of open crimp barrels (B-crimp)	98
Table A.5 – Minimum dimensions and tolerances for input funnel on a B-crimping zone.....	99
Table A.6 – Condition of position of wire insulation in the insulation grip.....	99
Table A.7 – Pull-out force recommended minimum values for electrolytic copper conductors with tensile strength 200 N/mm ² (e.g. according to EN 13602)	106
Table A.8 – Examples of pull-out force values (break) of commercially available European stranded conductors	107
Table A.9 – Examples of pull-out force values (break) of commercially available American stranded conductors.....	107
Table A.10 – Determination of the minimum pull-out forces in relation to the respective cross-sectional area and the intrinsic tensile strength of the conductor	108
Table A.11 – Pull-out force values for butt splice crimped connections	110

Table A.12 – Values for the support height L_a	116
Table A.13 – Condition of microsections	118
Table A.14 – Condition "Good" of insulation grip for B-crimp and O-crimp (asymmetrical and symmetrical overlap and enclosure crimp)	119
Table A.15 – Condition "PID" of insulation grip for B-crimp and O-crimp (asymmetrical and symmetrical overlap and enclosure crimp).....	120
Table A.16 – Condition "Fault" of insulation grip for B-crimp, O-crimp (asymmetrical and symmetrical overlap and enclosure crimp).....	120
Table A.17 – Features of splice crimp barrels	121
Table A.18 – Crimp resistance (maximum allowed initial values A) for $K = 1$ (electrolytic copper)	124
Table A.19 – Crimp resistance (after loading, R_{CR}) for $K = 1$ (electrolytic copper)	124
Table A.20 – Crimp resistance (maximum allowed initial values A) for $K \approx 3,8$ (nickel- brass, bright)	124
Table A.21 – Crimp resistance (after loading, R_{CR}) for $K \approx 3,8$ (nickel-brass, bright)	124
Table A.22 – Crimp resistance (maximum allowed initial values A) for $K = 6,4$ (tin- plated bronze).....	124
Table A.23 – Crimp resistance (after loading, R_{CR}) for $K = 6,4$ (tin-plated bronze).....	125

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SOLDERLESS CONNECTIONS –

Part 2: Crimped connections – General requirements, test methods and practical guidance

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60352-2 has been prepared by subcommittee 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2006 and Amendment 1:2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) the former Clauses 6 through 15 have been moved into a new informative Annex A titled "Practical guidance";

- b) several definitions have been added (conductor, wire, cable, crimping, crimped connection, crimp contact, terminal, terminal end, pre-insulated terminal end, termination, connecting device, splice, insulation support, insulation grip, pre-insulated crimped connection, crimping tool, locator, positioner, full cycle crimp mechanism, crimp anvil, crimp nest, crimp indenter, crimp height, crimp inspection hole, crimp barrel wire range, nominal cross-sectional area, geometric (actual) cross-sectional area, stranded conductor, crimp funnel, crimp depth, manufacturer, user, process indicator (PID));
- c) a three-level classification by end-product class has been introduced in Clause 4 Workmanship, based on the expected level of reliability of the end-use application for which the crimped connections under subject are suitable, similar to what was done in 4.3 of IEC 61191-1:2018 for soldered electrical and electronic assemblies;
- d) for better clarification, former subclause 4.5 Crimped connections, now renumbered and renamed 5.5 Prerequisites for crimped connections, has been split in several third level subclauses with assigned title;
- e) allowable strand damage has been introduced with reference to the classification in three levels by end-use application, for the production of test specimens;
- f) based on industry experience, in 5.3.1 the minimum copper content of a copper alloy suitable for making crimp barrels has been lowered to 57 % from original 60 %;
- g) the elongation at break of annealed copper suitable for conductors to be crimped has been increased to 15 % from original 10 %;
- h) the cross-sectional area of conductors for testing purposes is allowed to be the nominal (commercial) one, instead of the geometric (actual) one for wires with nominal cross-sectional area larger than 2,5 mm² (see 5.4.3), the geometric (actual) one being the reference in case of dispute on test results;
- i) consideration about wire insulation concentricity has been added in 5.4.5;
- j) former subclause 5.2.1 General examination is now renumbered and renamed as 7.1 General examination of crimp barrels and wires (examination of parts as called later) and a new subclause 7.2 Examination of crimp dimensions has been added, to cover examination of dimensions after crimping, with several new third-level subclauses: 7.2.1 Crimp height C_h , crimp width C_w and measurable crimp width C_{wm} , 7.2.2 Contact deformation after crimping, 7.2.3 Visual examination of insulation distance and conductor overhang, 7.2.4 Visual examination of splice crimped connections, 7.2.5 Visual examination of crimped connections on closed (machined) crimp barrels, 7.2.6 Visual examination of crimped connections on B-crimp open crimp barrels, 7.2.7 Visual examination of crimped connections with open crimp barrel with insulation grip;
- k) the pull-out force (tensile strength) requirements covering safety requirements of crimped connections in IEC 60352-2:2006, Table 1 have been kept, here renumbered Table 5; interpolated values for most used cross-sectional areas 0,34 mm² and 0,37 mm² have been added. Reference to IEC 61210 as source for these safety values has been removed, as partially inaccurate. Optional specification of higher pull-out force requirements, based on classification by end-use product as specified in 5.1, and more representative of what can be achieved based on the type of crimp barrel, the form of the crimping, the material and plating of barrel and wire, has been introduced in A.7.3;
- l) a microsection test (optional) has been added in 7.3.2;
- m) a vibration test (optional) has been added in 7.3.7;
- n) a current-carrying capacity test (optional) has been added in 7.4.3;
- o) an alternative current loading, cyclic test method has been added in 7.5.5;
- p) a flowing mixed gas corrosion test (optional) has been added in 7.6.2;
- q) crimping at low temperature (former subclause 5.4.2.5) has been completed in 7.5.6 by re-entering the test method already present in IEC 60352-2:1990, 11.4.5;
- r) types of test specimens have been expanded: a new type A specimen is added, type B is former type A, type C is former type B, type D is former type C, type E is former type D modified with addition of reference wires, type F is former type E, and new specimen types G and H were added to perform tests on splices;

s) normative references, as well as Bibliography, have been updated and expanded as required;

The text of this International Standard is based on the following documents:

Draft	Report on voting
48B/3110/FDIS	48B/3128/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60352 series, published under the general title *Solderless connections*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document includes requirements and relevant tests as well as practical guidance in Annex A for crimped connections.

Two test schedules are provided:

- the basic test schedule which applies to solderless crimped connections which conform to all of the prerequisites of Clause 5. It is derived from experience with successful applications of such connections;
- the full test schedule which applies to solderless crimped connections which do not fully conform to all prerequisites of Clause 5, for example which are made with solid wires, using materials or finishes not included in Clause 4.

This philosophy permits cost- and time-effective performance verification using a limited basic test schedule for established crimped connections and an expanded full test schedule for connections requiring more extensive performance validation.

A detail product specification or the manufacturer's specification for crimped connections or associated cable assemblies or both, as well as for crimp contacts, terminal ends or splices, can include additional tests to verify enhanced performance or conformance with specified product classes or both. It can also reference this document with test severities and acceptance criteria other than those provided by either one of the two test schedules, as well as foresee an intermediate test schedule. The requirements of the detail product specification or the manufacturer's specification prevail.

The suitability of the crimped connection implies that the specified requirements and tests apply to all factors involved in producing a suitable crimped connection, namely:

- the crimp barrel, which can be part of a splice, a terminal end or a crimp contact, the contact deemed to be used in a single-pole or multipole connector;
- the wire (or range of wires) for which the termination is suitable;
- the tools required to produce that type of solderless connection.

The practical guidance in Annex A serves as a guideline for the required workmanship. Attention is drawn to the fact that some industries (e.g. automotive, aerospace, nuclear, military) can have specific workmanship standards or quality requirements, or both, which are outside the scope of this document.

IEC Guide 109 advocates the need to minimize the impact of a product on the natural environment throughout the product life cycle.

It is understood that some of the materials permitted in this document can have a negative environmental impact.

As technological advances lead to acceptable alternatives for these materials, they will be eliminated from future editions of this document.

SOLDERLESS CONNECTIONS –

Part 2: Crimped connections – General requirements, test methods and practical guidance

1 Scope

This part of IEC 60352 is applicable to solderless crimped connections made with:

- appropriately designed uninsulated or pre-insulated crimp barrels as parts of crimp contacts, terminal ends or splices, and
- stranded wires of 0,05 mm² to 10 mm² cross-section or
- solid wires of 0,25 mm to 3,6 mm diameter;

for use in electrical and electronic equipment.

Information on the materials and data from industrial experience is included in addition to the test procedures to provide electrically stable connections under prescribed environmental conditions.

This part of IEC 60352 is not applicable to crimping of coaxial cables.

This part of IEC 60352 determines the suitability of solderless crimped connections as described above, under specified mechanical, electrical and atmospheric conditions and provides a means of comparing test results when the tools used to make the connections are of different designs or manufacture.

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 60050-581, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-60, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

IEC 60228, *Conductors of insulated cables*

IEC 60512-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 1: Generic specification*