

Solderless connections —

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

ICS 31.220.10

National foreword

This British Standard is the UK implementation of EN 60352-2:2006+A1:2013. It is identical to IEC 60352-2:2006 incorporating amendment 1:2013. It supersedes BS EN 60352-2:2006, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee EPL/48, Electromechanical components and mechanical structures for electronic equipment.

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

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**Solderless connections
Part 2: Crimped connections -
General requirements,
test methods and practical guidance
(IEC 60352-2:2006)**

Connexions sans soudure
Partie 2: Connexions serties -
Exigences générales,
méthodes d'essai et guide pratique
(CEI 60352-2:2006)

Lötfreie Verbindungen
Teil 2: Crimpverbindungen -
Allgemeine Anforderungen,
Prüfverfahren und Anwendungshinweise
(IEC 60352-2:2006)

This European Standard was approved by CENELEC on 2006-03-01. 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.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 48B/1584/FDIS, future edition 2 of IEC 60352-2, prepared by SC 48B, Connectors, of IEC TC 48, Electromechanical components and mechanical structures for electronic equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60352-2 on 2006-03-01.

This European Standard supersedes EN 60352-2:1994 + A1:1997 + A2:2002.

It includes the following major technical changes with respect to EN 60352-2:1994 and its amendments:

- a) the contents of clauses have been re-arranged, for example the old Clauses 5, 6, 7, 8 and 9 are now included in the new Clause 4, Requirements;
- b) Subclause 4.3.1, the material requirements for crimp barrels have been changed from Vickers hardness into more appropriate tensile strength requirements and the requirements have been opened to other materials, if it is of suitable characteristics;
- c) Subclause 4.3.3, Surface finishes: the tin-lead has been replaced by tin-alloy to comply with RoHS legislation. Other plating materials, such as nickel, may be used provided their suitability has been proven;
- d) Subclause 5.1.4, Recovering, has been added;
- e) Table 2, example of other materials, has been shortened;
- f) Subclause 5.2.4.5 and Figure 7, Current loading, cyclic: the length of wire between two specimens has been changed to a "*minimum of 150 mm*" to comply with regional requirements;
- g) Subclause 5.2.4.6, Crimping at low temperature, has been changed to "under consideration";
- h) Subclause 15.4 of amendment A1 has been deleted for the sake of design freedom, because the dimensions are not widely used as stated; only a minority of products, in most cases older ones have these dimensions.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2006-12-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2009-03-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60352-2:2006 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 48B/2340/FDIS, future IEC 60352-2:2006/A1, prepared by SC 48B, "Connectors", of IEC TC 48, "Electromechanical components and mechanical structures for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60352-2:2006/A1:2013.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2014-05-01
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2016-08-01

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

Endorsement notice

The text of the International Standard IEC 60352-2:2006/A1:2013 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

IEC 60352-2 includes requirements, tests and practical guidance information. Two test schedules are provided: a basic test schedule which applies to solderless crimped connections which conform to all of the requirements given in Clause 4 and a full test schedule which applies to solderless crimped connections which do not fully conform to all of the requirements, for example which are made with solid wires, different materials, etc.

IEC Guide 109 advocates the need to minimise 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 standard may have a negative environmental impact. As technological advances lead to acceptable alternatives for these materials, they will be eliminated from the standard.

SOLDERLESS CONNECTIONS –

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

1 Scope and object

This part of IEC 60352 is applicable to solderless crimped connections made with stranded wires of 0,05 mm² to 10 mm² cross-section or solid wires of 0,25 mm to 3,6 mm diameter and appropriately designed uninsulated or pre-insulated crimp barrels for use in telecommunication equipment and in electronic devices employing similar techniques.

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.

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

The object of this part of IEC 60352 is to determine the suitability of solderless crimped connections under specified mechanical, electrical and atmospheric conditions and to provide 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 referenced documents are indispensable for the application 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):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 581: Electro-mechanical components for electronic equipment*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*
Amendment 1 (1992)

IEC 60189-3:1988, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 3: Equipment wires with solid or stranded conductor, PVC insulated, in singles, pairs and triples*

IEC 60512 (all parts), *Connectors for electronic equipment – Tests and measurements*

IEC 60512-1-100:2001, *Connectors for electronic equipment – Tests and measurements – Part 1-100: General – Applicable publications*

IEC 60760:1989, *Flat, quick-connect terminations*
Amendment 1 (1993)

ISO 6892:1998, *Metallic materials – Tensile testing at ambient temperature*

3 Terms and definitions

For the purpose of this document, the terms and definitions of IEC 60050(581), IEC 60512-1 and the following apply:

3.1

crimp barrel

conductor barrel designed to accommodate one or more conductors and to be crimped by means of a crimping tool

3.2

open crimp barrel

crimp barrel with an open shape before crimping, for example U- or V-shape (see Figure 1)

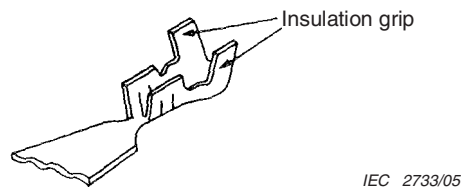


Figure 1 – Open crimp barrel

3.3

closed crimp barrel

crimp barrel with a closed shape before crimping (see Figure 2)

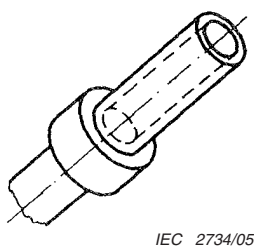


Figure 2a – Machined crimp barrel

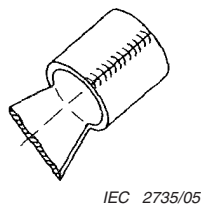


Figure 2b – Brazed/welded crimp barrel

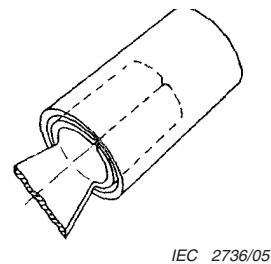


Figure 2c – Stamped/rolled crimp barrel

Figure 2 – Closed crimp barrels

3.4

pre-insulated crimp barrel

crimp barrel with a permanent layer of insulation through which the crimp is made (see Figure 3)

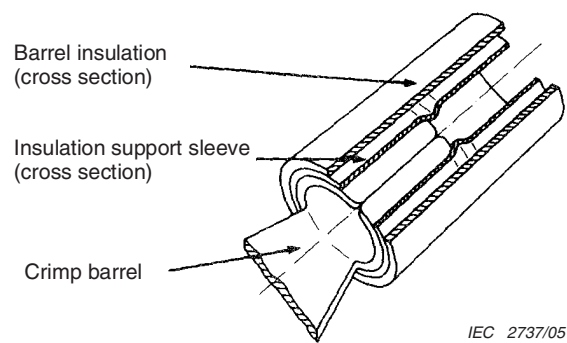


Figure 3 – Pre-insulated crimp barrel

3.5 crimping zone

that portion of a crimp barrel where the crimped connection is achieved by pressure deformation or reshaping of the barrel around the conductor (see Figure 4)

NOTE Where the crimp barrel is equipped with an insulation grip, this is also reshaped by compression by the crimping tool to secure the insulation of the wire.

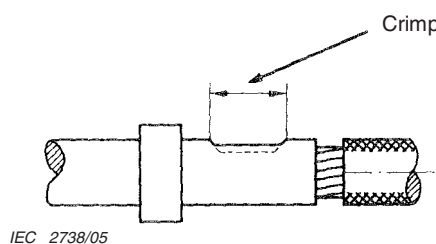


Figure 4a – Closed crimp barrel

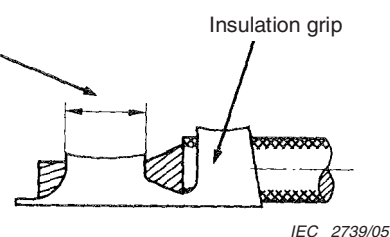


Figure 4b – Open crimp barrel

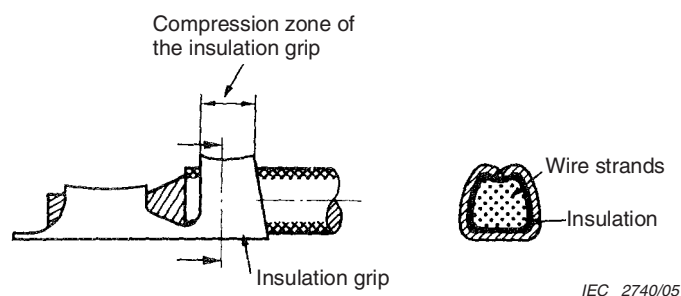


Figure 4c – Insulation grip

Figure 4 – Crimping zones

3.6 crimping die

that part of a crimping tool which forms the crimp(s) and usually incorporates the crimp anvil(s), the crimp indenter(s), and the positioner

NOTE Crimping dies may have separate or integral sections for compressing the insulation grip, if provided.

4 Requirements

4.1 Workmanship

The connection shall be processed in a careful and workmanlike manner, in accordance with good current practice.

4.2 Tools

Crimping tools shall be used and inspected according to the instructions given by the tool manufacturer.

The crimping tool shall be able to make uniformly reliable connections during its useful life.

The crimping tool shall be equipped with the appropriate dies. Where the dies are adjustable, the correct setting for the barrel to be crimped shall be used.

Hand crimping tools shall be provided with a full cycle crimping mechanism.

Automatic crimping tools shall be provided with a full cycle crimping mechanism or equivalent safeguard. They shall be correctly set and the setting shall be maintained.

Tools are evaluated by testing crimped connections made with the tools to be evaluated.

4.3 Crimp barrels

4.3.1 Materials

Crimp barrels shall be made of copper or copper alloy with a copper content of 60 % minimum.

The minimum tensile strength of the material shall not exceed 600 MPa in accordance with ISO 6892.

Other materials of suitable characteristics may be used, for example nickel, steel, stainless steel. Materials with a high resistivity-coefficient (K values, see 5.2.3.1) or materials exceeding the tensile strength specified above, may not be suitable for certain applications. In these cases, the full test schedule of 5.3.3 shall be applied (see 5.1.1).

4.3.2 Dimensions

The dimensions shall be suitable for stranded wires as specified in 4.4.

4.3.3 Surface finishes

The crimp barrel shall be unplated or plated with tin, tin-alloy, silver, gold or palladium.

The surface shall be free of contamination and corrosion. Other plating materials, such as nickel, (unless used as under-plate) may be used provided their suitability has been proven. In these cases, the full test schedule of 5.3.3 shall be applied (see 5.1.1).

4.3.4 Design features

The crimp barrel shall be so designed that the crimped connection is achieved by pressure deformation or reshaping of the crimp barrel around the stripped conductor.

NOTE Techniques where the connection is achieved by parts of barrel penetrating through the insulation of an insulated conductor are not covered by this standard.

The following barrel types shall be used:

- open crimp barrels, uninsulated;
- closed crimp barrel, either pre-insulated or uninsulated.

The crimp barrels shall be free of sharp edges likely to damage the conductors.

4.4 Wires

4.4.1 General

Stranded conductors shall be used, solid round conductors of 0,25 mm to 3,6 mm diameter may be used provided their suitability has been proven.

4.4.2 Materials

Annealed copper having an elongation at break of not less than 10 % shall be used.

4.4.3 Dimensions

The cross-section of the stranded conductor shall be within the range 0,05 mm² to 10 mm².

4.4.4 Surface finishes

Conductors which are unlabeled or finished with tin, tin-alloy or silver shall be used.

The surface shall be free of contamination and corrosion.

4.4.5 Insulation

The insulation shall be capable of being readily stripped from the conductor without changing the physical characteristics of the conductor or strands, respectively.

4.5 Crimped connections

The combination of the tool, barrel and wire shall be compatible.

Where the crimp barrel is equipped with an insulation support or insulation grip, the overall diameter of the insulation wire shall be compatible with the dimensions of the support or grip.

The wire shall be stripped to the correct length. The strands of the stripped part of the conductor shall not be damaged, for example partly or totally broken.

The stripped part of the conductor shall be clean and free from particles of insulation.

The lay of the strands shall be correct. If the lay has been disturbed, it may be restored by a light twist.

The conductor shall be correctly located in the barrel, i.e. to the correct depth. This shall be verified as follows:

- in the case of open crimp barrels or closed crimp barrels with inspection provision, this shall be visually checked;
- in the case of closed crimp barrels without inspection provisions, for example an inspection hole, this shall be measured (indirectly by measuring the possible insertion depth of the barrel, the stripping length of the wire and the distance between the end of the barrel and the beginning of the wire insulation).

All strands of the wire shall be within the barrel. There shall be no damaged strands.

Where the crimp barrel is equipped with an insulation support or insulation grip, the insulation shall be correctly located in the support or grip.

NOTE For crimped connections made with more than one wire, see 10.2.

5 Tests

5.1 Testing

5.1.1 General

As explained in the introduction, there are two test schedules which shall be applied according to the following conditions:

- crimped connections, which conform to all of the requirements of Clause 4 shall be tested to and meet the requirements of the basic test schedule of 5.3.2;
- crimped connections, which do not fully conform to all of the requirements of Clause 4, for example which are made with solid wires, different materials, etc., shall be tested to and meet the requirements of the full test schedule of 5.3.3.

NOTE For crimped connections made with more than one wire, see 10.2.

5.1.2 Standard conditions for testing

Unless otherwise specified, all tests shall be carried out under the standard conditions for testing as specified in IEC 60512-1.

The ambient temperature and the relative humidity at which the measurements are made shall be stated in the test report.

In case of dispute about test results, the test shall be repeated at one of the referred conditions of IEC 60068-1.

5.1.3 Preconditioning

Where specified, the connection shall be preconditioned under standard conditions for testing for a period of 24 h, in accordance with IEC 60512-1.

5.1.4 Recovering

Where specified, the specimen shall be allowed to recover under standard conditions for testing for a period of 1 h to 2 h, after conditioning.

5.1.5 Mounting of the specimen

When mounting is required in a test, the specimens shall be mounted using the normal mounting method, unless otherwise specified.

5.2 Test methods and test requirements

5.2.1 General examination

The tests shall be carried out in accordance with test 1a of IEC 60512 and test 1b of IEC 60512. The visual examination test may be carried out with magnification up to approximately five times.

All crimp connections shall be examined to ensure that the applicable requirements of 4.3 to 4.5 have been met.

5.2.2 Mechanical tests

5.2.2.1 Pull out force

The test shall be carried out in accordance with test 16d of IEC 60512.

Unless otherwise specified by the manufacturer of the crimp barrel (terminal), the minimum values of the pull out force given in Table 1 shall be applied.

Table 1 – Pull out force of crimped connections

Conductor cross-section		Pull out force
mm ²	AWG ^a	N
0,05	30	6
0,08	28	11
0,12	26	15
0,14		18
0,22	24	28
0,25		32
0,32	22	40
0,5	20	60
0,75		85
0,82	18	90
1,0		108
1,3	16	135
1,5		150
2,1	14	200
2,5		230
3,3	12	275
4,0		310
5,3	10	355
6,0		360
8,4	8	370
10,0		380
NOTE To test the crimped connection, the same values are included in IEC 60760, Clause 17 and IEC 61210, Table 9.		
^a For information only.		

5.2.2.2 Insulation grip effectiveness

The test shall be carried out in accordance with test 16h of IEC 60512.

Number of winding cycles: 2

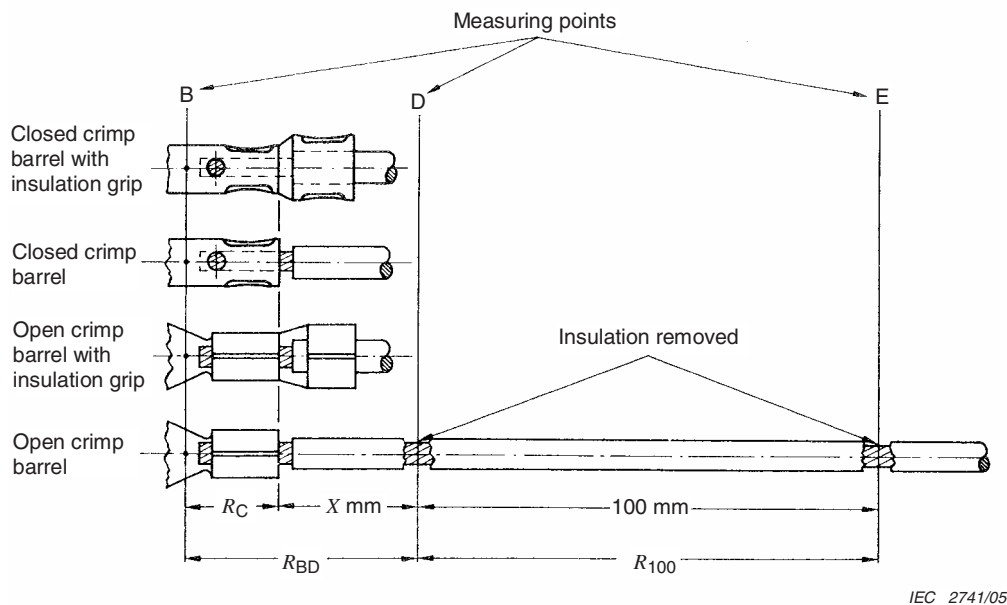
Tension to be applied: Lowest tension necessary to bring the wire into contact with the mandrel.

5.2.3 Electrical tests

5.2.3.1 Contact resistance

The test shall be carried out in accordance with test 2a of IEC 60512 or with test 2b of IEC 60512, as specified in the detail specification.

A suitable test arrangement is shown in Figure 5.



$$R_C = R_{BD} - \frac{X}{100} \times R_{100}$$

where

R_C is the contact resistance of crimped connection;

R_{BD} is the measured resistance between measuring points B and D;

R_{100} is the measured distance over 100 mm wire length (D – E);

X is the distance between crimp barrel and measuring point D in mm.

NOTE For distance X , 25 mm to 100 mm is recommended.

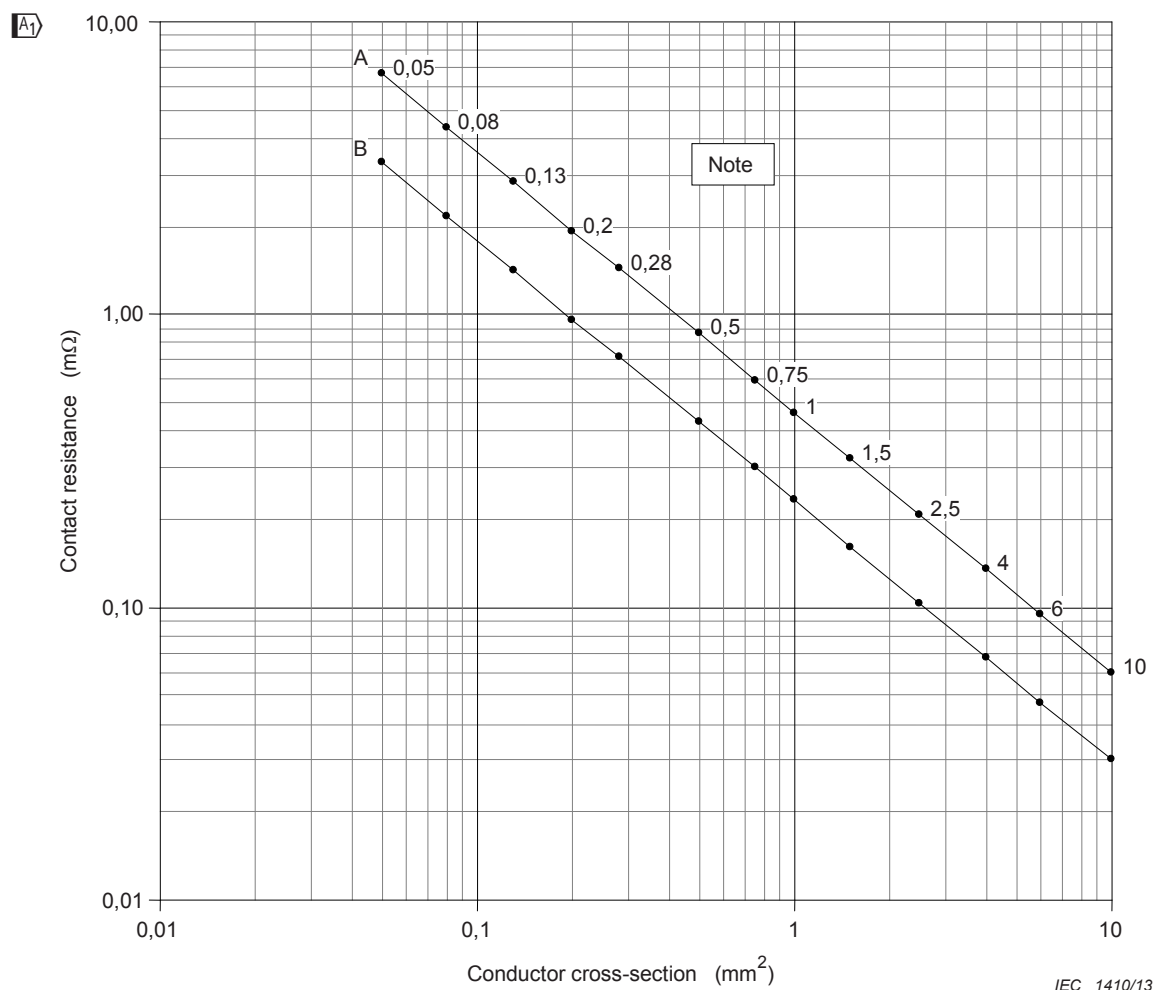
Figure 5 – Test arrangement for measurement of contact resistance

Contact point B shall be as close as possible to the end of the wire in the crimp barrel but, in the case of an open crimp barrel, not touching the end of the wire.

To achieve dependable and reproducible test results, good contact to all strands at the measuring points is necessary. By locating the measuring point D at a safe distance away from the crimped connection, any means to ensure the necessary good contact to all strands may be used.

A suitable test device shall be used to ensure good contact at all measuring points. The test device shall ensure that the measuring points are located at predetermined fixed distances. Where test probes are used, they shall be sufficiently rounded to avoid damaging the conductor strands.

When test 2b of IEC 60512 is applied, the test current shall be 1 A per mm² conductor cross-section. The duration of application of the test current shall be short enough to prevent heating of the specimens.



Curve A: Values for initial contact resistance, maximum.

Curve B: Values for maximum change in resistance after electrical or climatic conditioning.

NOTE Numbers indicate specific conductor cross-sections in mm².

The lines for maximum initial contact resistance (A) and maximum change in resistance after electrical or climatic conditioning (B) are based on the following equations. These formulas may be used in place of the graph in Figure 6 to determine the maximum allowed initial resistance and post-conditioning change in resistance values.

$$A = 0,4596 \times C^{-0,8843}$$

$$B = A / 2$$

Where:

A is the maximum allowed initial resistance, in milliohms (mΩ);

B is the maximum allowed change in resistance, in milliohms (mΩ);

C is the wire cross-section, in mm².

Figure 6 – Contact resistance R_c of crimped connections with copper barrels and copper conductor ($K = 1$) **A1**

The cross-section to be used when applying Figure 6 is the cross-section calculated with the number of strands and the nominal diameter of one strand.

The values for maximum initial contact resistance (curve A) and the values for maximum change in resistance (curve B) as presented in Figure 6 apply only to crimped connections made with crimp barrels according to 4.3 and conductors according to 4.4 and where $K = 1$.

For barrel materials other than copper, the values of both curves A and B are to be multiplied by " K ", where

$$K = \frac{\text{resistivity of material used}}{\text{resistivity of copper}}$$

Table 2 includes values of resistivity and K for other materials.

Table 2 – Example of other materials

Material	Resistivity $\Omega \text{ mm}^2/\text{m}$	K
Annealed copper, 100,0 Cu	0,017 2	1
Copper-zinc alloys (brasses)	0,030 to 0,061	1,74 to 3,55
For example 70,0 Cu, 30,0 Zn	0,061	3,55
Copper-tin alloys (bronzes)	0,083 to 0,15	4,83 to 8,72
For example 94,0 Cu, 6,0 Sn	0,11	6,40

The maximum permitted change in resistance is to be added to the initially measured resistance, not to the permitted initial limit, i.e. the maximum permitted contact resistance after conditioning is equal to the measured initial value plus the maximum permitted change as given in curve B of Figure 6 and corrected by " K ", if applicable.

NOTE For crimped connections made with more than one wire, see 10.2. For further information on wires, see IEC 60189-3.

5.2.3.2 Voltage proof (crimped connection with pre-insulated crimp barrels)

The test shall be carried out in accordance with test 4c of IEC 60512.

Proof voltage: 1 500 V r.m.s. 45 Hz to 60 Hz unless otherwise agreed between user and manufacturer.

5.2.4 Climatic tests

5.2.4.1 General

Unless otherwise specified, the following upper category temperature (UCT) and lower category temperature (LCT) shall be used in the following tests:

UCT : +125 °C (for tin plated barrels +100 °C)

LCT : –55 °C

5.2.4.2 Rapid change of temperature

The test shall be carried out in accordance with test 11d of IEC 60512.

The following details shall apply:

Low temperature:	T_A	LCT
High temperature	T_B	UCT
Duration of exposure:	t_1	30 min
Number of cycles:		5