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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Solderless connections –
Part 7: Spring clamp connections – General requirements, test methods and practical guidance

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SOLDERLESS CONNECTIONS –

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60352-7 has been prepared by subcommittee SC 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

This second edition cancels and replaces the first edition of IEC 60352-7, published in 2002. This edition constitutes a technical revision.

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

a) correction of the two flow charts in Figure 6 and Figure 7,
b) split the content into more clauses for better separation between full test schedule and basic test schedule,
c) relocating the content of former Clause 6 Practical guidance into an informative Annex A, as now common in the IEC 60352 series for solderless connections,
d) clarification on conductor types with reference to classes defined in IEC 60228.

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

FDIS	Report on voting
48B/2823/CDV	48B/2851/RVC

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

This document was drafted in accordance with ISO/IEC Directives, Part 2.

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 "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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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 part of IEC 60352 covers spring clamp connections and includes requirements, tests and practical guidance information.

Two test schedules are provided.

a) The basic test schedule applies to spring clamp connections which conform to all requirements of Clause 5. These requirements are derived from experience with successful applications of such spring clamp connections.

b) The full test schedule applies to spring clamp connections which do not fully conform to all requirements of Clause 5, for example which are manufactured using materials or finishes not included in Clause 5.

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

The values given in this document are minimum values, which are harmonized with other IEC documents. Other standards may specify other values.

SOLDERLESS CONNECTIONS –

Part 7: Spring clamp connections – General requirements, test methods and practical guidance

1 Scope ~~and object~~

This part of IEC 60352 is applicable to spring clamp connections made with stripped wire without further preparation:

- solid conductors of 0,32 mm to 3,7 mm nominal diameter (0,08 mm^2 to 10 mm^2 cross-section), or
- stranded conductors of 0,08 mm^2 to 10 mm^2 cross-section, or
- flexible conductors of 0,08 mm^2 to 10 mm^2 cross-section,

according to IEC 60228 or IEC 60189-3 for use in ~~telecommunication~~ electrical and electronic equipment and ~~in electronic devices employing similar techniques~~ components.

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

The object of this document is to determine the suitability of spring clamp connections under specified mechanical, electrical and atmospheric conditions.

NOTE 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 ~~may~~ can have a negative environmental impact. As technological advances lead to acceptable alternatives for these materials, they will be eliminated from this document.

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):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 581: Electro-mechanical components for electronic equipment*~~
~~Amendment 1 (1998)~~

IEC 60068-1:~~1988~~2013, *Environmental testing – Part 1: General and guidance*
~~Amendment 1 (1992)~~

IEC 60189-3:~~1988~~2007, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 3: Equipment wires with solid or stranded conductor wires, PVC insulated, in singles, pairs and triples*

IEC 60228:~~1978~~2004, *Conductors of insulated cables*
~~Amendment 1 (1993)~~

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

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

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

IEC 60512-1-1, *Connectors for electronic equipment – Tests and measurements – Part 1-1: General examination – Test 1a: Visual examination*

IEC 60512-1-2, *Connectors for electronic equipment – Tests and measurements – Part 1-2: General examination – Test 1b: Examination of dimension and mass*

IEC 60512-2-1, *Connectors for electronic equipment – Tests and measurements – Part 2-1: Electrical continuity and contact resistance tests – Test 2a: Contact resistance – Millivolt level method*

IEC 60512-2-2, *Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2b: Contact resistance – Specified test current method*

IEC 60512-2-5, *Connectors for electronic equipment – Tests and measurements – Part 2-5: Electrical continuity and contact resistance tests – Test 2e: Contact disturbance*

IEC 60512-6-4, *Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal)*

IEC 60512-9-2, *Connectors for electronic equipment – Tests and measurements – Part 9-2: Endurance tests – Test 9b: Electrical load and temperature*

IEC 60512-11-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 11-1: Climatic tests – Test 11a – Climatic sequence*

IEC 60512-11-4, *Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature*

IEC 60512-11-7, *Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test*

IEC 60512-16-20, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 16: Mechanical tests on contacts and terminations – Section 20: Test 16t: Mechanical strength (wired termination of solderless connections)*

~~IEC 60884-1:1994, *Plug and socket-outlets for household and similar purposes – Part 1: General requirements*~~

3 Terms and definitions

~~For the purpose of this part of IEC 60352, the terms and definitions of IEC 60050(581) and IEC 60512-1 and the following additional terms and definitions apply:~~

For the purposes of this document, the following terms and definitions 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
spring clamp termination
part of the contact or terminal to which one single conductor only is connected by means of a spring

3.1.1
universal spring clamp termination
spring clamp termination intended to accept solid, stranded and flexible unprepared conductors

Note 1 to entry: For the meaning of solid, stranded and flexible, see IEC 60228 where conductors are classified as class 1 (solid conductors), class 2 (stranded conductors), class 5 (flexible conductors) and class 6 (flexible conductors which are more flexible than class 5).

3.1.2
non-universal spring clamp termination
spring clamp termination intended to accept conductors of one class only, for example solid conductors only, or conductors of two classes only, for example solid and stranded but not flexible

Note 1 to entry: For the meaning of solid, stranded and flexible, see IEC 60228 where conductors are classified as class 1 (solid conductors), class 2 (stranded conductors), class 5 (flexible conductors) and class 6 (flexible conductors which are more flexible than class 5).

3.1.3
push-in spring clamp termination
non-universal spring clamp termination in which the connection is made by pushing in a solid or stranded conductor without the aid of a tool or of an actuating element

Note 1 to entry: For the meaning of solid and stranded, see IEC 60228 where solid conductors are classified as class 1, stranded conductors are classified as class 2.

3.2
spring clamp connection
solderless connection achieved by clamping a conductor with a spring clamp termination

SEE: Figure 1

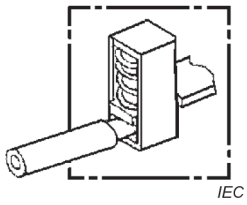


Figure 1a – Spring clamp connection, operated without a tool

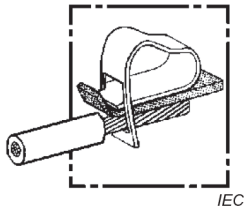


Figure 1b – Spring clamp connection, operated with a tool

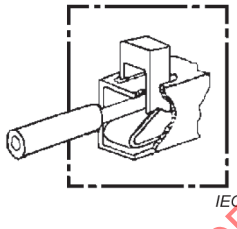


Figure 1c – Spring clamp connection, operated with an actuating element

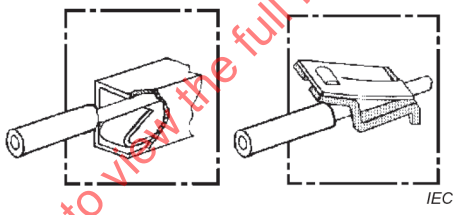


Figure 1d – Spring clamp connections, with a push-in spring clamp termination, with solid wires

Figure 1 – Examples of spring clamp connections

3.3
spring clamp terminal
terminal designed to accept a conductor for the purpose of establishing a spring clamp connection

SEE: Figure 2

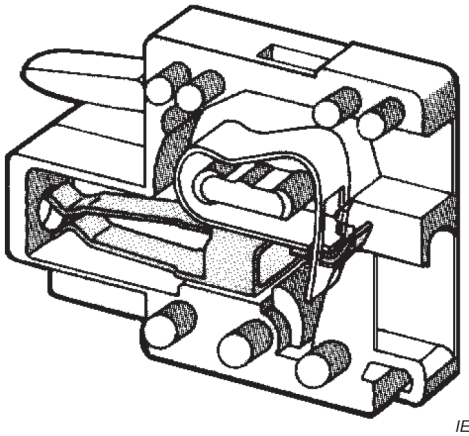


Figure 2 – Example of a spring clamp terminal

3.4
spring clamp connecting device
device for the electrical connection of one or more conductors comprising one or more spring clamp terminations and, if necessary, insulation and/or auxiliary parts

3.5
actuating element
part of a spring clamp termination or terminal to which an external force is to be applied, and the resulting movement of ~~the actuating element~~ which provides a means for activating or deactivating the spring

~~[IEV 581-11-09, modified]~~

4 Requirements

4.1 Workmanship

The connection shall be processed in a careful and workmanlike manner, in accordance with good current practice. Annex A (informative) provides practical guidance and may constitute a benchmark for the assessment of workmanship.

NOTE Some industry sectors (e.g. automotive, aerospace, marine, nuclear, military) use workmanship standards which can be considered upon agreement between manufacturer and user.

4.2 Tools

Tools, if necessary, shall be used and inspected according to the instructions given by the manufacturer.

5 Pre-requisites for basic test schedule

5.1 Spring clamp terminations

5.1.1 Materials

– Materials for the current-carrying parts:

suitable grades of copper or copper alloy shall be used.

– Materials for the spring clamp parts:

suitable (according to manufacturer's instructions) grades of copper alloy or steel shall be used.

5.1.2 Surface finishes

The contact area of the current-carrying parts shall be plated with tin or tin-alloy.

The surface shall be free of detrimental contamination or corrosion.

5.1.3 Design features

Spring clamp terminations shall be designed so that the spring clamp parts establish a ~~sufficient force to produce a reliable connection~~ force to connect the conductors which ensures that the necessary contact pressure is maintained.

In a spring clamp connecting device, each conductor shall be clamped individually.

The openings for use of a tool intended to assist the insertion or withdrawal of the conductor shall be clearly distinguishable from the conductor's entry hole.

5.1.4 Dimensions

The suitability of a spring clamp connection depends on the dimensions of the termination together with the characteristics of the materials used.

The dimensions of the termination shall be chosen so as to be suitable for ~~the wire~~ (i.e. able to accept) the cross-sectional area of the conductor or the range of ~~wires~~ conductors for which the termination is designed.

The suitability is verified by applying the test schedules given in Clause 8.

5.2 Wires

5.2.1 General

Wires with solid, stranded and flexible conductors according to IEC 60228 or IEC 60189-3 shall be used depending on the type of spring clamp terminations.

5.2.2 Materials

The conductor used shall be made of annealed copper.

5.2.3 Dimensions

Wires with the following dimensions shall be used:

- solid wires of 0,32 mm to 3,7 mm nominal diameter (0,08 mm^2 to 10 mm^2 cross-section), or
- stranded wires of 0,08 mm^2 to 10 mm^2 cross-section, or
- flexible wires of 0,08 mm^2 to 10 mm^2 cross-section.

5.2.4 Surface finishes

The conductor shall be unplated or plated with tin or tin-alloy.

The conductor surface shall be free of contamination and corrosion which degrades performance.

5.2.5 Wire insulation

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

5.3 Spring clamp connections

a) The combination of ~~wire~~ conductor and spring clamp termination shall be compatible.

b) The wire shall be stripped to the correct length specified by the manufacturer. The stripped part of the ~~conductor~~ wire shall not be damaged and shall be clean and free from particles of insulation.

c) The conductor shall be correctly located in the spring clamp termination at the correct depth specified by the manufacturer.

All strands of the wire shall be within the spring clamp termination.

6 ~~Tests~~ Testing

6.1 General

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

a) spring clamp connections which conform to all the requirements of Clause 5 shall be tested in accordance with and meet the requirements of the basic test schedule, see 8.2;

b) spring clamp connections which do not fully conform to all the requirements of Clause 5, for example, those which are made with different wire types and/or termination sizes and/or materials, shall be tested and meet the requirements of the full test schedule given in 8.3.

6.2 Standard conditions for testing

Unless otherwise specified, all tests shall be carried out under 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~~ test conditions ~~of~~ for referee measurements and tests set out in IEC 60068-1.

6.3 Preconditioning

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

6.4 Recovery

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.

6.5 Mounting of specimen

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

b) Each test specimen shall consist of one spring clamp connection prepared as required in the test schedules.

~~NOTE~~ When more test specimens are required, they may be part of the same multipole spring clamp connecting devices.

~~**5.2 Test methods and test requirements**~~

~~NOTE As far as test methods are described in this standard, it is intended that the description will be replaced by a reference to the appropriate part of IEC 60512 as soon as the relevant test method is included in IEC 60512. IEC 60512-1-100 contains a list of test methods and the relevant parts of the IEC 60512 series.~~

7 Tests

7.1 General examination

The examination shall be carried out in accordance with Test 1a~~: Visual examination,~~ of IEC 60512-1-1, and Test 1b~~: Examination of dimension and mass,~~ of IEC 60512-1-2. The visual examination test may be carried out with magnification up to approximately five times.

All spring clamp terminations and wires shall be examined to ensure that the applicable requirements of Clause 5 have been met.

7.2 Mechanical tests

7.2.1 Tensile strength

The test shall be carried out in accordance with Test 16t~~: Mechanical strength (wired terminations of solderless connections)~~, method A, of IEC 60512-16-20.

Requirement:

The tensile strength of spring clamp connections shall be not less than specified in Table 1, unless otherwise specified by the detail specification.

Table 1 – Values of tensile strength

~~Conductor cross-section~~ ~~mm²~~	~~Values of tensile strength~~ ~~N min.~~
~~≥0,08~~	~~4~~
~~0,22~~	~~10~~
~~0,34~~	~~15~~
~~0,5~~	~~20~~
~~0,75~~	~~30~~
~~1,0~~	~~35~~
~~1,5~~	~~40~~
~~2,5~~	~~50~~
~~4,0~~	~~60~~
~~6,0~~	~~80~~
~~10,0~~	~~90~~

Conductor cross-section mm²	Values of tensile strength N minimum
0,08 up to 0,22 (not included)	4
0,22	10
0,34	15
0,5	20
0,75	30
1,0	35
1,5	40
2,5	50
4,0	60
6,0	80
10,0	90

7.2.2 Wire deflection

NOTE This test method is ~~in accordance with the deflection test of~~ similar to the deflection test method for screwless terminals described in IEC 60884-1.

Spring clamp terminations shall be so designed that the inserted solid conductor remains clamped, even when the conductor has been deflected during normal installation, for example, during mounting in a box, and the deflecting stress is transferred to the spring clamp termination.

Compliance is checked by the following test which is made on specimens which have not been used for any other test.

a) Test apparatus

The test apparatus, the principle of which is shown in Figure 3, shall be so constructed that:

– a specified conductor, properly inserted into a terminal, is allowed to be deflected in any of the 12 directions differing from each other by 30°, with a tolerance referred to each direction of ±5° and;

– the starting point can be varied by 10° and 20° from the original point.

~~NOTE~~ A reference direction need not be specified.

The deflection of the conductor from its straight position to the testing positions shall be effected by means of a suitable device applying a specified force to the conductor at a certain distance from the terminal.

The deflecting device shall be so designed that:

– the force is applied in the direction perpendicular to the undeflected conductor;

– the deflection is attained without rotation or displacement of the conductor within the clamping unit, and

– the force remains applied whilst the prescribed voltage drop measurement is made.

Provisions shall be made so that the voltage drop across the spring clamp termination under test can be measured when the conductor is connected, as shown for example in Figure 3.

b) Test method

The specimen is mounted on the fixed part of the test apparatus in such a way that the specified conductor inserted into the spring clamp termination under test can be freely deflected.

The surface of the test conductor shall be free of detrimental contamination or corrosion.

NOTE ~~1~~ If necessary, the inserted conductor ~~may~~ can be permanently bent around obstacles, so that these do not influence the results of the test.

~~NOTE 2~~ In some cases, with the exception of the case of guidance for the conductors, it may be advisable to remove those parts of the specimen which do not allow the deflection of the conductor corresponding to the force to be applied.

A spring clamp termination is fitted as for normal use with a solid copper conductor having the smallest cross-sectional area as specified by the manufacturer and is submitted to a first test sequence; unless the first test sequence has failed, the same spring clamp termination is submitted to a second test sequence using the conductor having the largest cross-sectional area.

The force for deflecting the conductor is specified in Table 2, the distance of 100 mm being measured from the extremity of the terminal, including the guidance for the conductor, if any, to the point of application of the force to the conductor.

The test is made with continuous current (i.e. the current is not switched on and off during the test); a suitable power supply should be used so that the current variations are kept within ±5 % during the test.

Table 2 – Values of force for wire deflection test

~~Cross-section of the test conductor~~ ~~mm²~~	~~Force for deflecting the test conductor[a]~~ ~~N~~
~~≤0,5~~	~~0,09~~
~~0,75~~	~~0,16~~
~~1,0~~	~~0,25~~
~~1,5~~	~~0,5~~
~~2,5~~	~~1,0~~
~~4~~	~~2,0~~
~~6~~	~~3,5~~
~~10~~	~~7,0~~
~~[a] The forces are chosen so that they stress the conductors close to the limit of elasticity.~~	

Cross-section of the test conductor mm²	Force for deflecting the test conductors N
0,5 up to 0,75 (not included)	0,09
0,75	0,16
1,0	0,25
1,5	0,5
2,5	1,0
4	2,0
6	3,5
10	7,0
The forces are chosen so that they stress the conductors close to the limit of elasticity.	

c) Test procedure

A tenth of the test current assigned to the wire according to Table 4 is passed through the spring clamp connection under test. A force, according to Table 2, is applied to the test conductor inserted in the spring clamp termination under test in the direction of one of the 12 directions shown in Figure 3 and the voltage drop across this spring clamp connection is measured. The force is then removed.

The force is then applied successively in each of the remaining 11 directions shown in Figure 3 following the same test procedure.

If at any of the 12 test directions the voltage drop is greater than 2,5 mV, the force is kept applied in this direction until the voltage drop is reduced to a value below 2,5 mV, but for not more than 1 min. After the voltage drop has reached a value lower than or equal to 2,5 mV, the force is kept applied in the same direction for a further period of 30 s during which period the voltage drop shall not have increased.

The other specimens of the set are tested following the same test procedure, but moving the 12 directions of the force so that they differ by approximately 10° for each specimen. If one specimen of the set has failed at one of the directions of application of the test force, the tests are repeated on another set of specimens, all of which shall comply with the repeated tests.

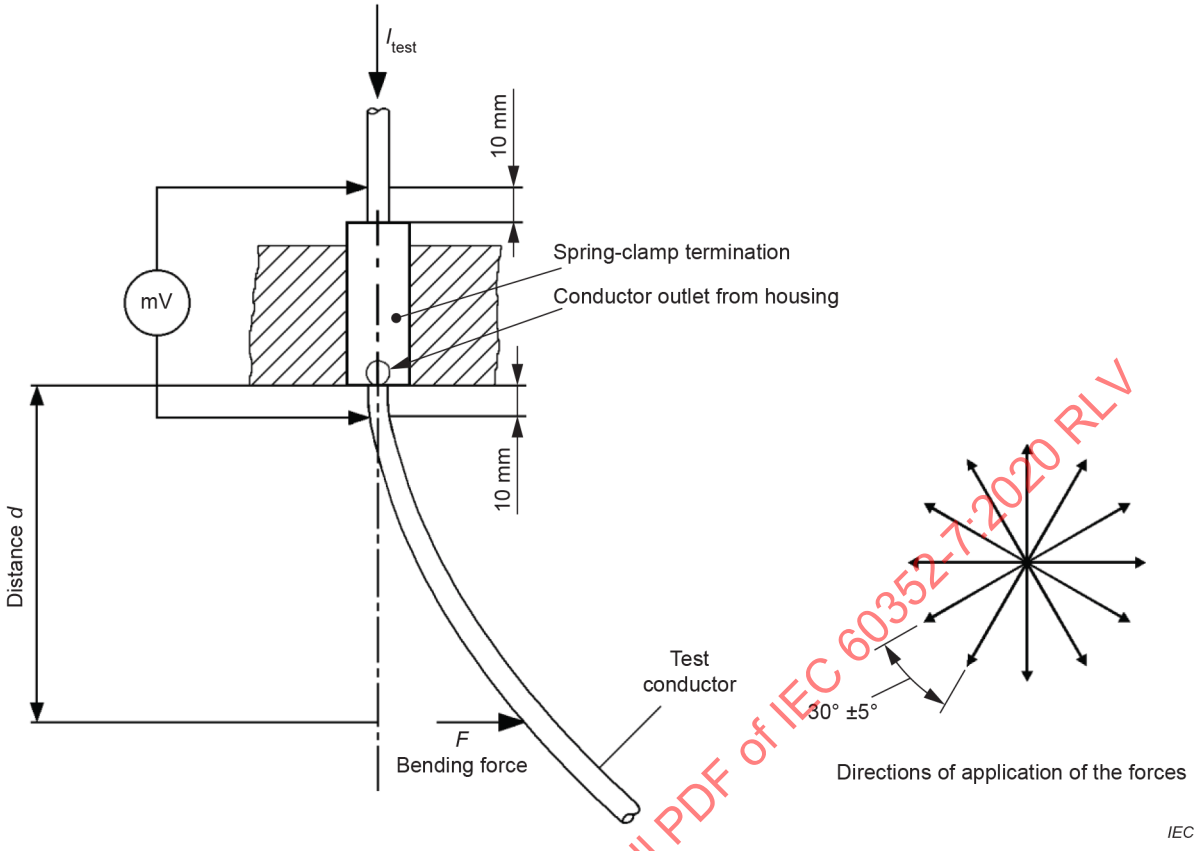


Figure 3 – Information for the wire deflection test

7.2.3 Vibration

The test shall be carried out in accordance with Test 6d~~: Vibration,~~ of IEC 60512-6-4.

The component shall be firmly held on a vibration table.

An example of a suitable test arrangement for testing a component containing a spring clamp connection is shown in Figure 4. Contact disturbance shall be monitored during the vibration test in accordance with Test 2e~~: Contact disturbance,~~ of IEC 60512-2-5, see Table 3.

The limit of duration of contact disturbance shall be 1 µs unless otherwise specified by the detail specification.

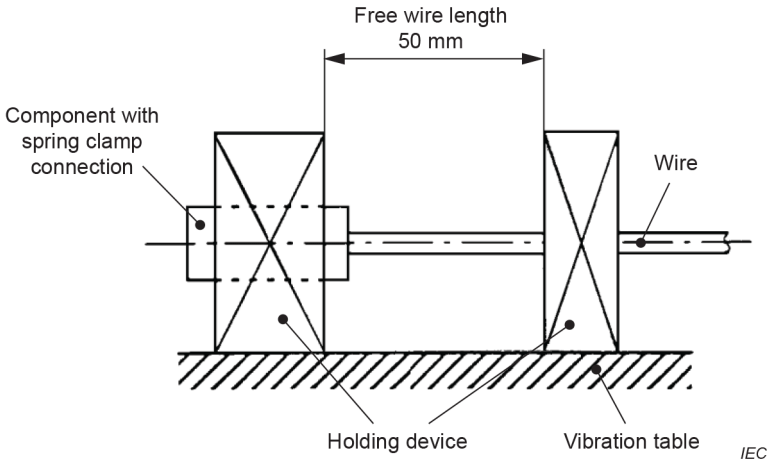


Figure 4 – Test arrangement, vibration

Table 3 – Vibration, test severities

Range of frequency, Hz	10 to 55	10 to 500	10 to 2 000
Overall duration, h	2,25	6	7,5
Displacement amplitude below the cross-over frequency, mm	0,35	0,35	1,5
Acceleration amplitude above the cross-over frequency, m/s^2	–	50	200
Directions	3 axes	3 axes	3 axes
Number of sweep cycles per direction	10	10	10

Unless otherwise specified, the test shall be carried out in the 10 Hz to 55 Hz range.

7.2.4 Repeated connections and disconnections

The object of this test is to assess the ability of a spring clamp termination with a wire range specified by the manufacturer to withstand a specified number of connections and disconnections.

If the termination is designed to accept a range of conductor sizes:

- for the smallest conductor
  - all cycles but the last one shall be carried out with the largest conductor size specified. The last cycle and the final measurement shall be carried out with the smallest conductor size specified.
- for the largest conductor
  - all cycles shall be carried out with the largest conductor size specified. The final measurement shall be carried out with the largest conductor size specified.

A stripped wire of the largest size specified shall be inserted into the spring clamp termination under test in the specified manner. After this, the conductor shall be extracted in the specified manner. This shall be considered as one test cycle.

The last of the specified number of test cycles consists of only inserting the unprepared stripped wire into the termination, so as to have a spring clamp connection at the end of the specified number of test cycles.

The same spring clamp termination shall be submitted to all the required number of test cycles.

A new part of the wire or a new wire of the same type shall be used for each test cycle.

Test severities:

The conductor cross-section for the last cycle and the number of cycles to be carried out shall be specified by the detail specification or by the manufacturer. Preferred values for the number of cycles are 4, 20 or 100.

7.3 Electrical tests

7.3.1 Contact resistance

The test shall be carried out in accordance with Test 2a~~: Contact resistance – Millivolt level method, or Test 2b: Contact resistance – Specified test current method,~~ of IEC 60512-2-1 or Test 2b of IEC 60512-2-2, as specified in the relevant specification.

A suitable test arrangement is shown in Figure 5.

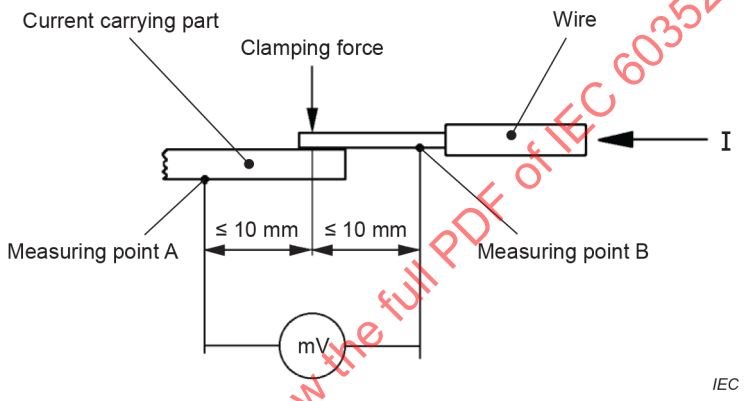


Figure 5 – Test arrangement, current method

Measuring point A shall be as close as possible to the end of the wire in the spring clamp connection but not touching the end of the conductor.

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

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

When Test 2b is applied, the test current shall be 1/10 of the rated current of the wire according to Table 4, unless otherwise specified by the detail specification.

The maximum contact resistance shall not exceed the lower of the following values:

– either the values of the maximum contact resistance of Table 4, or
– 2,5 times the initial values of the measurement.

Table 4 – Rated current of the wires, initial and final contact resistance

~~Conductor cross-section~~ ~~mm²~~	~~Nominal current~~ ~~A~~	~~Initial contact resistance~~ ~~max. mΩ~~	~~Maximum contact resistance after electrical, climatic, dynamic conditioning~~ ~~mΩ~~
~~0,08~~	~~1~~	~~10~~	~~20~~
~~0,22~~	~~4~~	~~4~~	~~8~~
~~0,34~~	~~5~~	~~3~~	~~6~~
~~0,5~~	~~6~~	~~2,5~~	~~5~~
~~0,75~~	~~9~~	~~1,7~~	~~3,4~~
~~1,0~~	~~13,5~~	~~1,1~~	~~2,2~~
~~1,5~~	~~17,5~~	~~0,8~~	~~1,6~~
~~2,5~~	~~24~~	~~0,6~~	~~1,2~~
~~4,0~~	~~32~~	~~0,45~~	~~0,9~~
~~6,0~~	~~41~~	~~0,35~~	~~0,7~~
~~10,0~~	~~57~~	~~0,25~~	~~0,5~~

Conductor cross-section mm²	Rated current A	Initial contact resistance mΩ max.	Contact resistance after electrical, climatic, dynamic conditioning mΩ max.
0,08	1	10	20
0,22	4	4	8[1)]
0,34	5	3	6[1)]
0,5	6	2,5	5[1)]
0,75	9	1,7	3,4[1)]
1,0	13,5	1,1	2,2[1)]
1,5	17,5	0,8	1,6[1)]
2,5	24	0,6	1,2[1)]
4,0	32	0,45	0,9[1)]
6,0	41	0,35	0,7[1)]
10,0	57	0,25	0,5[1)]

[1)] SOURCE: IEC 60947-7-1:2009, Table 4.

7.3.2 Electrical load and temperature

The test shall be carried out in accordance with Test 9b~~: Electrical load and temperature,~~ of IEC 60512-9-2. Unless otherwise specified by the detail specification, the following details shall apply:

Maximum operating temperature:	+85 °C (UCT)
Test duration:	1 000 h
Test current:	as specified in IEC 60592-9-2.

~~Test current shall be as specified in the detail specification.~~

For devices suitable for a range of conductors, this test shall be performed with the conductor cross-section as specified in the detail specification.

7.4 Climatic tests

7.4.1 General

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

7.4.2 Rapid change of temperature

The test shall be carried out in accordance with Test 11d~~: Rapid change of temperature,~~ of IEC 60512-11-4.

Unless otherwise specified by the detail specification, the following details shall apply:

low temperature:	T_A	−40 °C (LCT)
high temperature:	T_B	+85 °C (UCT)
duration of exposure:	t_1	30 min
number of cycles:		5

7.4.3 Climatic sequence

The test shall be carried out in accordance with Test 11a~~: Climatic sequence,~~ of IEC 60512-11-1. Unless otherwise specified by the detail specification, the following details shall apply:

– dry heat
  test temperature: 85 °C (UCT)
– cold
  test temperature: −40 °C (LCT)
– damp heat
  remaining cycle: 1

NOTE This climatic sequence differs from the standard sequence according to IEC 60512-11-1 in that it foresees carrying out the damp heat test after the cold test, rather than before it. For this reason, it keeps the denomination "remaining cycle" even if it is the first and only cycle foreseen.

7.4.4 Flowing mixed gas corrosion test

The test shall be carried out in accordance with Test 11g~~: Flowing mixed gas corrosion test,~~ of IEC 60512-11-7.

Unless otherwise specified by the detail specification, the following details shall apply:

Method:	1
Duration of exposure:	10 days

NOTE This test is a method with two mixed gases.

H_2S: 100 ± 20 (10^{-9} vol/vol).

SO_2: 500 ± 100 (10^{-9} vol/vol).

8 Test schedules

8.1 General

Where the requirements of the test sequence for a component employing these connections include all or part of the test requirements of this specification, duplication of testing shall be excluded.

Prior to testing, specimens shall be ~~made~~ prepared. Each specimen shall consist of a spring clamp termination with one ~~wire~~ conductor inserted.

When connections with terminations designed to be suitable for a range of wire dimensions are to be tested, the tests shall be carried out:

a) with the number of specimens specified in Table 5 connected with wires having the minimum conductor dimensions within the range,

and additionally

b) with the number of specimens specified in Table 5 connected with wires having the maximum conductor dimensions within the range.

When multipole spring clamp connecting devices are to be tested, the required number of specimens shall be distributed uniformly.

Before the specimens are prepared, it shall be verified that:

c) the correct spring clamp terminations and wires are used;

d) where the connections are made by tools:
   – the correct tool is used;
   – the tool works correctly;

e) the operator is able to produce spring clamp connections which comply with 5.3.

Table 5 – Number of specimens required

Test schedule	Subclause	Required in all cases
Basic test schedule, 8.2	8.2.3 –	10 or 2 × 10 –
Full test schedule, 8.3	8.3.3.2 8.3.3.3 8.3.3.4 8.3.3.5	5 or 2 × 5 5 or 2 × 5 5 or 2 × 5 5 or 2 × 5

8.2 Basic test schedule

8.2.1 General

Where the basic test schedule is applicable (see 6.1 a)), the number of specimens specified in Table 5 shall be prepared and subjected to the initial examination according to 8.2.2.

8.2.2 Initial examination

All specimens shall be subjected to Test 1a~~: Visual examination,~~ of IEC 60512-1-1.

8.2.3 Testing of spring clamp connections with spring clamp terminations with and without a specified wire range

10 specimens, or 2 × 10 specimens.

In those cases where the termination covers a range of wire sizes, specimens shall be selected for a maximum wire size and the same number for the minimum wire size within the range.

After initial examination, 8.2.2, all specimens shall be divided into two test groups: 5 specimens or 2 × 5 specimens as applicable, shall be subjected to the tests of Table 6.

Table 6 – Test group P1

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
P1.1			Contact resistance	2a or 2b	7.3.1
P1.2	Wire deflection	7.2.2			
P1.3	Vibration	7.2.3	Contact disturbance	6d and 2e	7.2.3
P1.4			Contact resistance	As in P1.1	7.3.1

After initial examination, 8.2.2, the remaining 5 specimens, or 2 × 5 specimens as applicable, shall be subjected to the tests set out in Table 7.

Table 7 – Test group P2

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
P2.1	Repeated connections and disconnections	7.2.4			
P2.2	Tensile strength	7.2.1	Mechanical strength	16t	7.2.1

8.3 Full test schedule

8.3.1 General

Where the full test schedule is necessary (see 6.1 b)), the required number of specimens specified in Table 5 shall be prepared and subjected to the initial examination according to 8.3.2.

8.3.2 Initial examination

All specimens required shall be subjected to Test 1a~~: Visual examination,~~ of IEC 60512-1-1.

8.3.3 Testing of spring ~~type~~ clamp connections with and without a specified wire range

8.3.3.1 General

20 specimens, or 2 × 20 specimens.

In those cases where the termination covers a range of wire sizes, specimens shall be selected for a maximum wire size and the same number for the minimum wire size within the range.

These specimens shall be divided into four test groups.

8.3.3.2 Test group A

5 specimens, or 2 × 5 specimens as applicable, shall be subjected to the tests set out in Table 8.

Table 8 – Test group A

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
~~AP2.1~~ AP1	Repeated connections and disconnections	7.2.4			
AP2~~.2~~	Tensile strength	7.2.1	Mechanical strength	16t	7.2.1

8.3.3.3 Test group B

5 specimens, or 2 × 5 specimens as applicable, shall be subjected to the tests set out in Table 9.

Table 9 – Test group B

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
BP1			Contact resistance	2a or 2b	7.3.1
BP2	Wire deflection	7.2.2			
BP3	Electrical load and temperature	7.3.2		9e	7.3.2
BP4			Contact resistance	As BP1	7.3.1

8.3.3.4 Test group C

5 specimens, or 2 × 5 specimens as applicable, shall be subjected to the tests set out in Table 10.

Table 10 – Test group C

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
CP1	Repeated connections and disconnections	7.2.4			
CP2			Contact resistance	2a or 2b	7.3.1
CP3	Vibration	7.2.3	Contact disturbance	6d and 2e	7.2.3
CP4	Rapid change of temperature	7.4.1		11d	
CP5	Climatic sequence	7.4.2		11a	
CP6			Contact resistance	As CP1	7.3.1

8.3.3.5 Test group D

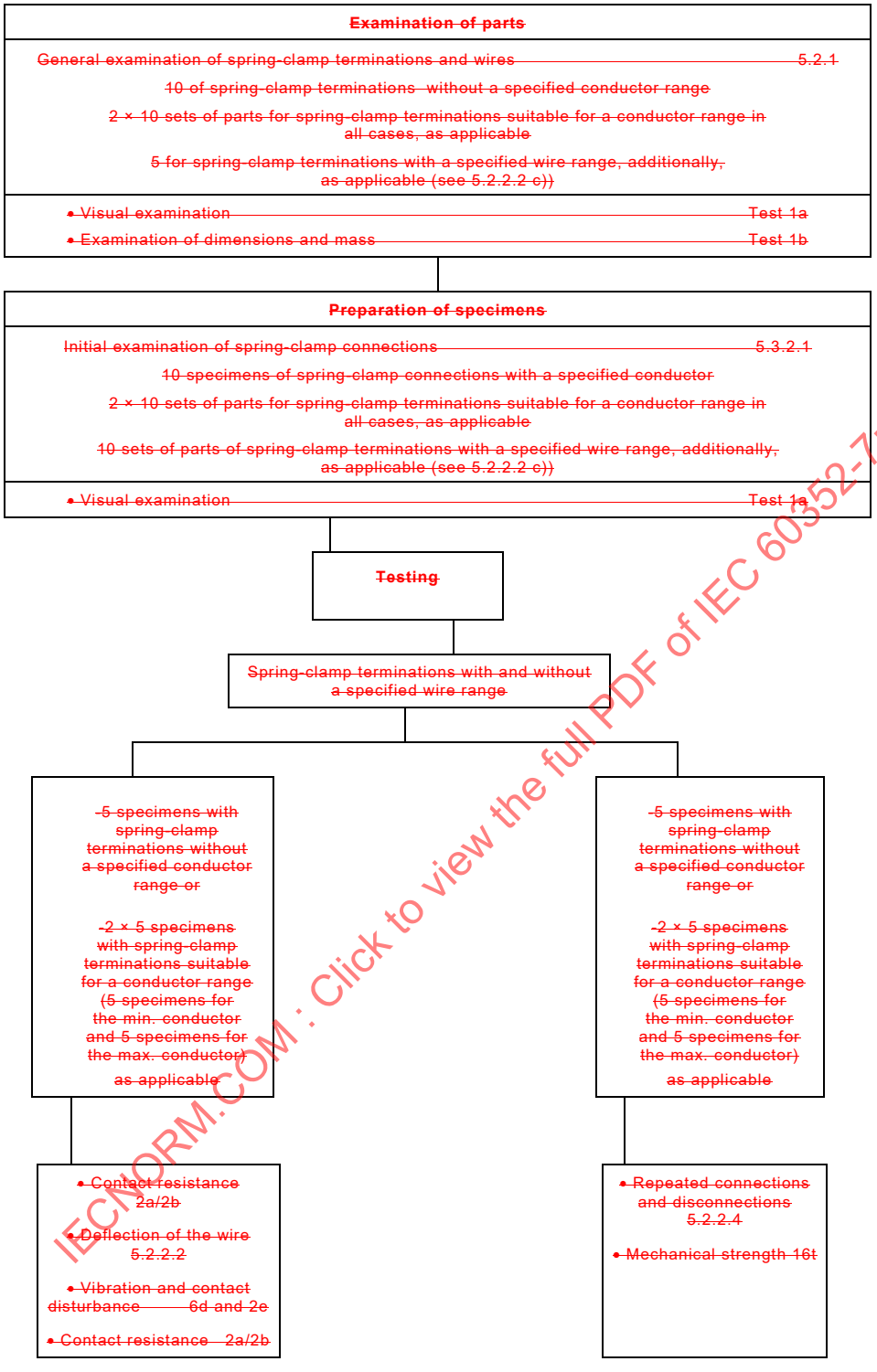
5 specimens, or 2 × 5 specimens as applicable, shall be subjected to the tests set out in Table 11.

Table 11 – Test group D

Test phase	Test		Measurement to be performed		Requirement
	Title	Subclause	Title	IEC 60512 Test No.	Subclause
DP1	Repeated connections and disconnections	7.2.4			
DP2			Contact resistance	2a or 2b	7.3.1
DP3	Flowing mixed gas corrosion test	7.4.3		11g	
DP4			Contact resistance	As DP1	7.3.1

8.4 Flow charts

For quick orientation, the test schedules detailed in 8.2 and 8.3 are repeated as flow charts in a simplified manner in Figure 6 and Figure 7.



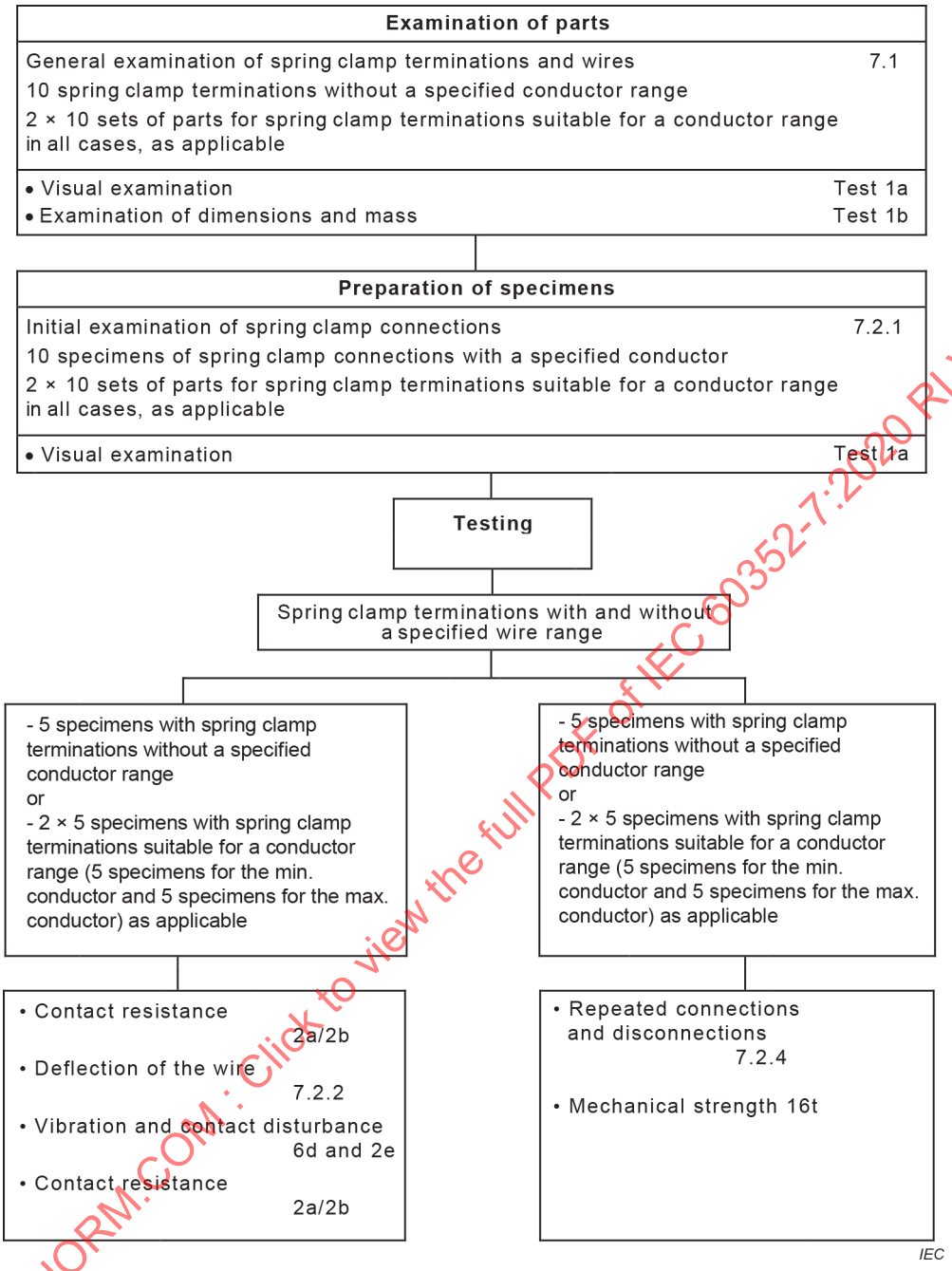
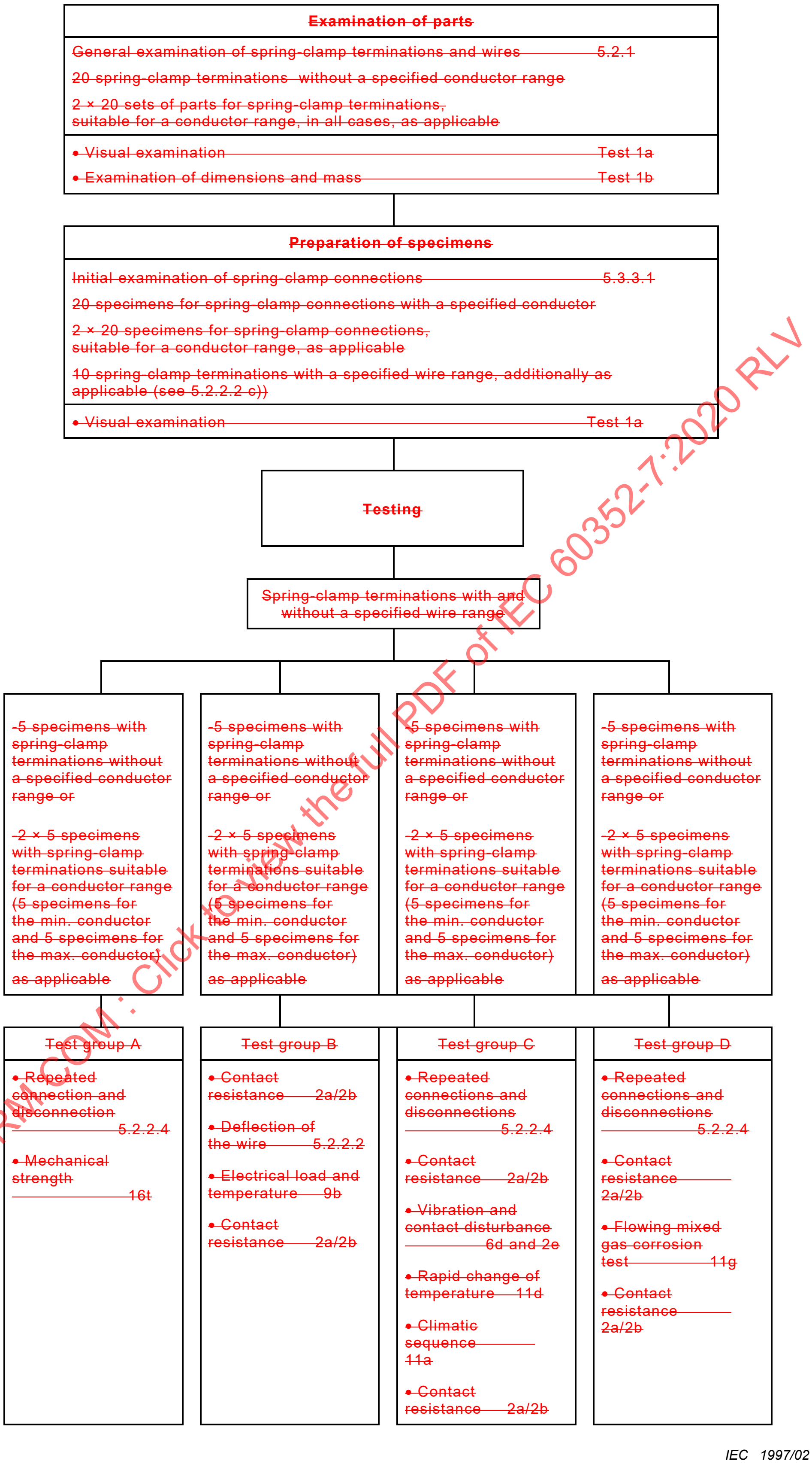


Figure 6 – Basic test schedule (see 8.2)



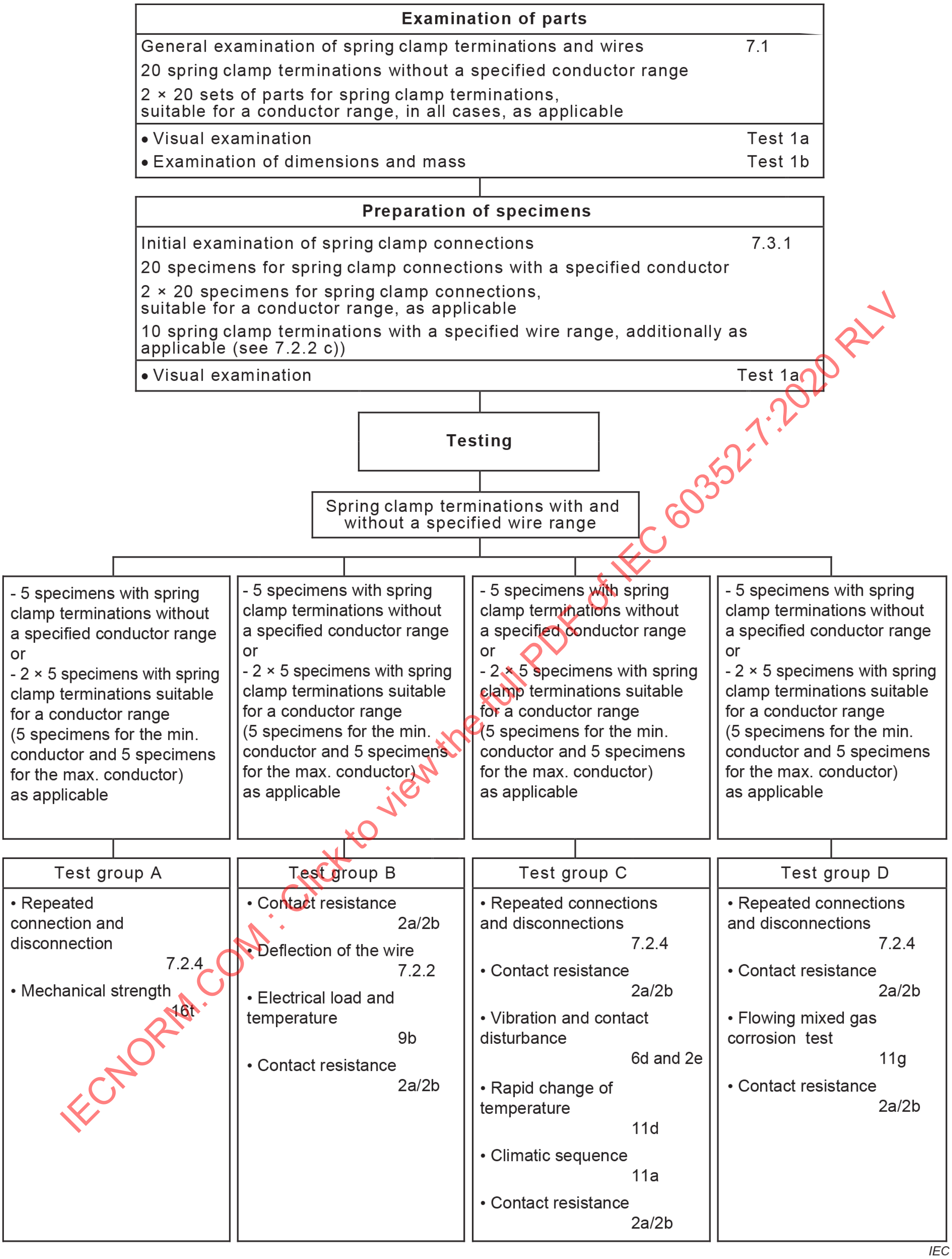


Figure 7 – Full test schedule (see 8.3)

Annex A
(informative)

Practical guidance

A.1 Current-carrying capacity

A spring clamp connection ~~should~~ shall be suitable for carrying the current assigned to the wire cross-section specified in the detail specification.

Care should be taken ~~that~~ since the current-carrying capacity can be influenced by:

~~– contact material;~~
~~– surface finish of the contact;~~
~~– cross-section of the conductor;~~
~~– surface finish of the conductor.~~

– contact material;
– conductor material
– conductor cross-section;
– contact surface finish;
– conductor surface finish.

A.2 Tool information

If the manufacturer of the spring clamp termination provides or prescribes a tool for operating the spring clamp of the termination, this shall be used.

A.3 Termination information

A.3.1 General

The following information is based on industrial experience.

A.3.2 Design features

A.3.2.1 General

Spring clamp terminations are intended to accept solid, stranded or flexible conductors as indicated in 5.2.3 unless otherwise specified by the manufacturer.

Spring clamp terminations are intended to accept unprepared conductors.

A.3.2.2 Types of spring clamp terminations

A.3.2.2.1 Universal spring clamp terminations

Universal spring clamp terminations are intended to accept solid, stranded and flexible unprepared conductors.

Connections of universal spring clamp terminations with inserted conductors are shown in Figure 1 a), Figure 1 b) and Figure 1 c).

A.3.2.2.2 Non-universal spring clamp terminations

A non-universal spring clamp termination is a termination for the connection and disconnection of a specific type of conductor only, for example solid (class 1) conductors only or a special combination of ~~wire~~ conductor types, like solid (class 1) and stranded ~~wires~~ (class 2) conductors but not flexible ~~wire~~ (class 5 or 6) conductors. The manufacturer shall define the type of conductors the non-universal spring-clamp termination can accept.

The manufacturer may also indicate whether a non-universal spring clamp termination deemed to accept e.g. solid (class 1) conductors is also suitable for use in combination with flexible (class 5) conductors previously prepared e.g. by a crimped wire end sleeve, either pre-insulated or non-insulated, including under which additional conditions – if any – e.g. a reduction of maximum conductor size, any additional tools, etc. Practices such as those suggested in A.4.1 and Clause A.5 are also to be considered.

A connection of non-universal spring clamp terminations with inserted conductors is shown in Figure 1 d).

A.3.2.2.3 ~~Push wire~~ Push-in spring-clamp termination

~~A non-universal spring-clamp termination in which the connection is made by pushing in a solid or stranded conductor.~~

As defined in 3.1.3, a push-in spring clamp connection is a non-universal spring clamp termination in which the connection is made by pushing in a solid (class 1) or stranded (class 2) conductor.

Two different push-in spring clamp connections of non-universal spring clamp terminations with inserted conductors are shown in Figure 1 d).

A.3.3 Materials

Materials for the spring clamp termination are specified in 5.1.1.

Normally, spring clamp terminations are intended to clamp copper conductors.

Under moist conditions, other conductors showing a large difference of electrochemical potential with respect to the spring clamp termination shall not be used without special preparation.

A.3.4 Surface finishes

The plating materials specified in 5.1.2 are normally used. Unplated terminations or other plating materials may be used, provided their suitability has been proven. In this case, the full test schedule of 8.3 shall be applied (see 6.1).

A.4 Wire information

A.4.1 General

Unprepared conductor means a conductor which has been cut and the insulation has been stripped only for insertion into the spring clamp termination.

NOTE A conductor the shape of which is arranged for introduction into a clamping unit or the strands of which are twisted to consolidate the end, is considered to be an unprepared conductor.

The manufacturer may recommend the use of appropriate wire preparation and tools required.

The ends of flexible or stranded conductors may be tinned or soldered, as the spring clamp prevents the risk of poor contact due to cold flow of the solder.

A.4.2 Materials

According to 5.2.2, conductors made of annealed copper are commonly used for spring clamp connections.

The following additional conductor materials may be used:

– copper alloys;
– nickel alloys.

In these cases, the full test schedule of 8.3 shall be applied (see 6.1).

A.4.3 Surface finishes

Unplated conductors or conductors finished with tin or tin-alloy are normally used (see 5.2.4).

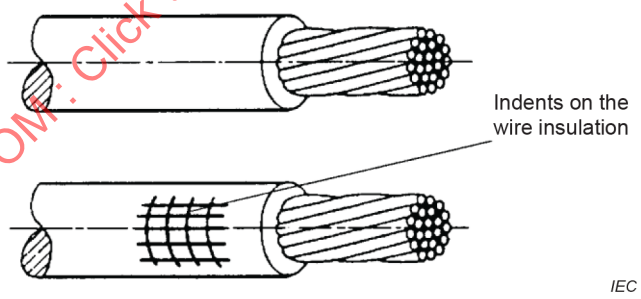
The surface shall be free of detrimental contamination or corrosion.

Other plating materials, such as silver or nickel, may be used. In this case, the full test schedule of 8.3 shall be applied (see 6.1).

A.4.4 Stripping information

In order to obtain a good and stable spring clamp connection, it is necessary to meet the requirements for the correct stripping of the wire. The required stripping length depending on the type and size of the spring clamp termination used shall be given by the manufacturer.

A correctly stripped wire is shown in Figure A.1, while Figure A.2 shows some examples of stripping faults which shall be avoided.



~~NOTE~~ Indents on the wire insulation caused by the stripping tools which do not damage the insulation are permitted.

Figure A.1 – Correctly stripped wire

To avoid damaging the conductor during stripping, the blades of the stripping tools should be adapted according to the conductor diameter and the thickness of insulation.

The following examples of stripping faults are often caused by:

– inappropriate handling;
– incorrect adjustment of the stripping tools;
– damaged stripping blades of the stripping tool.

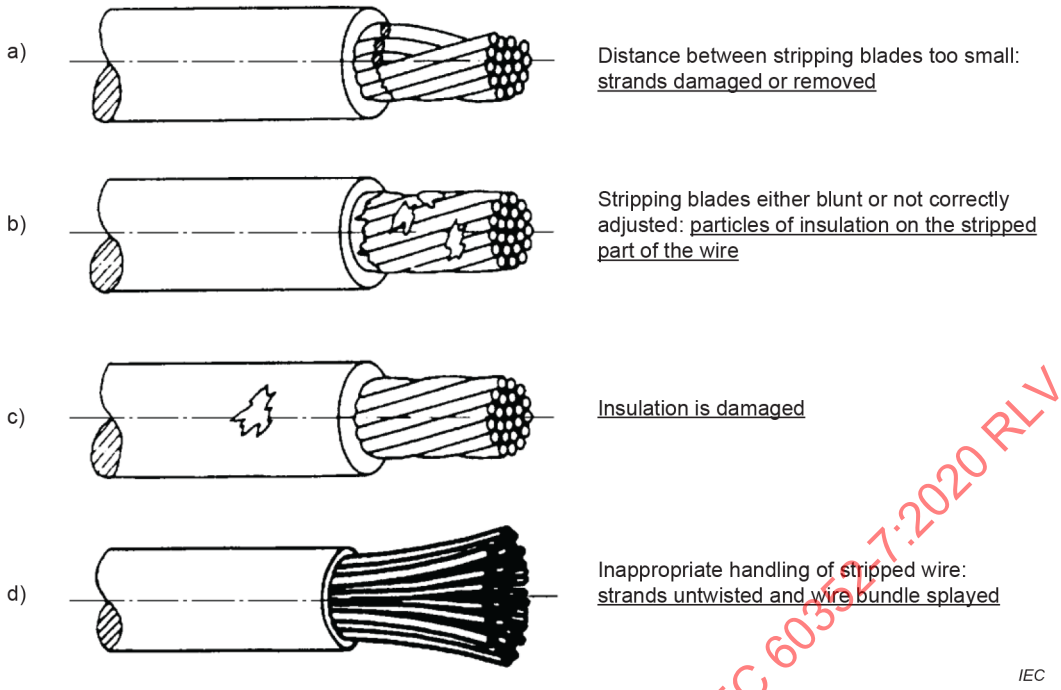


Figure A.2 – Examples of stripping faults

A.5 Connection information

There are different types of spring clamp connections in use. Therefore, it is important to choose the permitted combination of wire and spring clamp termination.

The insertion and withdrawal of the conductors are intended to be made in accordance with the manufacturer's instructions.

If it is necessary to use a tool (for example screw-driver) for operating the spring of the termination, the appropriate size given by the manufacturer should be applied.

Terminals should be designed and constructed so that:

– each conductor is clamped individually;

– during the connection or disconnection the conductors can be connected or disconnected either at the same time or separately.

The connection of the conductor should be made:

– either by the use of a general purpose tool or a convenient device integral with the terminal to open it and to assist the insertion or the withdrawal of the conductor (for example for universal terminals);

– or by simple insertion.

For the disconnection of the conductor, an operation other than a pull only on the conductor is necessary (for example for ~~push-wire~~ push-in terminals).

The wire should be stripped to the length given by the relevant detail specification without damaging the strands of the stripped part of the conductor. The stripped part should be clean and free from particles of insulation.

Notice should be taken that all strands of the flexible conductor are completely inserted.

Special care should be taken during the insertion of wires with small sizes because of low stiffness of the strands.

Bibliography

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

IEC 60512-9-5, *Connectors for electrical and electronic equipment – Tests and measurements – Part 9-5: Endurance tests – Test 9e: Current loading, cyclic*

IEC 60884-1:2002, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*
IEC 60884-1:2002/AMD1:2006
IEC 60884-1:2002/AMD2:2013

IEC 60947-7-1:2009, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

IEC Guide 109:2012, *Environmental aspects – Inclusion in electrotechnical product standards*

IEC 60352-7

Edition 2.0 2020-12

INTERNATIONAL STANDARD

Solderless connections – Part 7: Spring clamp connections – General requirements, test methods and practical guidance

IEC 60352-7:2020-12(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SOLDERLESS CONNECTIONS –

Part 7: Spring clamp 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.
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International Standard IEC 60352-7 has been prepared by subcommittee SC 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

This second edition cancels and replaces the first edition of IEC 60352-7, published in 2002. This edition constitutes a technical revision.

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

a) correction of the two flow charts in Figure 6 and Figure 7,
b) split the content into more clauses for better separation between full test schedule and basic test schedule,
c) relocating the content of former Clause 6 Practical guidance into an informative Annex A, as now common in the IEC 60352 series for solderless connections,

d) clarification on conductor types with reference to classes defined in IEC 60228.

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

FDIS	Report on voting
48B/2823/CDV	48B/2851/RVC

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

This document was drafted in accordance with ISO/IEC Directives, Part 2.

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 "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

This part of IEC 60352 covers spring clamp connections and includes requirements, tests and practical guidance information.

Two test schedules are provided.

a) The basic test schedule applies to spring clamp connections which conform to all requirements of Clause 5. These requirements are derived from experience with successful applications of such spring clamp connections.

b) The full test schedule applies to spring clamp connections which do not fully conform to all requirements of Clause 5, for example which are manufactured using materials or finishes not included in Clause 5.

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

The values given in this document are minimum values, which are harmonized with other IEC documents. Other standards may specify other values.

SOLDERLESS CONNECTIONS –

Part 7: Spring clamp connections – General requirements, test methods and practical guidance

1 Scope

This part of IEC 60352 is applicable to spring clamp connections made with stripped wire without further preparation:

- solid conductors of 0,32 mm to 3,7 mm nominal diameter (0,08 mm^2 to 10 mm^2 cross-section), or
- stranded conductors of 0,08 mm^2 to 10 mm^2 cross-section, or
- flexible conductors of 0,08 mm^2 to 10 mm^2 cross-section,

according to IEC 60228 or IEC 60189-3 for use in electrical and electronic equipment and components.

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

The object of this document is to determine the suitability of spring clamp connections under specified mechanical, electrical and atmospheric conditions.

NOTE 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 this document.

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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60189-3:2007, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 3: Equipment wires with solid or stranded conductor wires, PVC insulated, in singles, pairs and triples*

IEC 60228:2004, *Conductors of insulated cables*

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

IEC 60512-1-1, *Connectors for electronic equipment – Tests and measurements – Part 1-1: General examination – Test 1a: Visual examination*

IEC 60512-1-2, *Connectors for electronic equipment – Tests and measurements – Part 1-2: General examination – Test 1b: Examination of dimension and mass*

IEC 60512-2-1, *Connectors for electronic equipment – Tests and measurements – Part 2-1: Electrical continuity and contact resistance tests – Test 2a: Contact resistance – Millivolt level method*

IEC 60512-2-2, *Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2b: Contact resistance – Specified test current method*

IEC 60512-2-5, *Connectors for electronic equipment – Tests and measurements – Part 2-5: Electrical continuity and contact resistance tests – Test 2e: Contact disturbance*

IEC 60512-6-4, *Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal)*

IEC 60512-9-2, *Connectors for electronic equipment – Tests and measurements – Part 9-2: Endurance tests – Test 9b: Electrical load and temperature*

IEC 60512-11-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 11-1: Climatic tests – Test 11a – Climatic sequence*

IEC 60512-11-4, *Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature*

IEC 60512-11-7, *Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test*

IEC 60512-16-20, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 16: Mechanical tests on contacts and terminations – Section 20: Test 16t: Mechanical strength (wired termination of solderless connections)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
spring clamp termination
part of the contact or terminal to which one single conductor only is connected by means of a spring

3.1.1
universal spring clamp termination
spring clamp termination intended to accept solid, stranded and flexible unprepared conductors

Note 1 to entry: For the meaning of solid, stranded and flexible, see IEC 60228 where conductors are classified as class 1 (solid conductors), class 2 (stranded conductors), class 5 (flexible conductors) and class 6 (flexible conductors which are more flexible than class 5).

3.1.2
non-universal spring clamp termination
spring clamp termination intended to accept conductors of one class only, for example solid conductors only, or conductors of two classes only, for example solid and stranded but not flexible

Note 1 to entry: For the meaning of solid, stranded and flexible, see IEC 60228 where conductors are classified as class 1 (solid conductors), class 2 (stranded conductors), class 5 (flexible conductors) and class 6 (flexible conductors which are more flexible than class 5).

3.1.3
push-in spring clamp termination
non-universal spring clamp termination in which the connection is made by pushing in a solid or stranded conductor without the aid of a tool or of an actuating element

Note 1 to entry: For the meaning of solid and stranded, see IEC 60228 where solid conductors are classified as class 1, stranded conductors are classified as class 2.

3.2
spring clamp connection
solderless connection achieved by clamping a conductor with a spring clamp termination

SEE: Figure 1

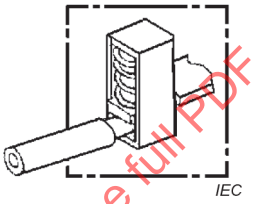

Figure 1a – Spring clamp connection, operated without a tool

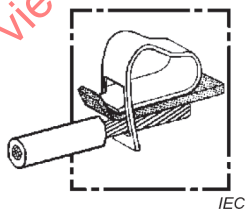

Figure 1b – Spring clamp connection, operated with a tool

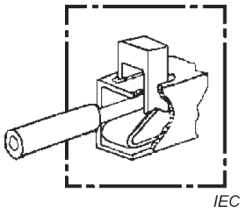

Figure 1c – Spring clamp connection, operated with an actuating element

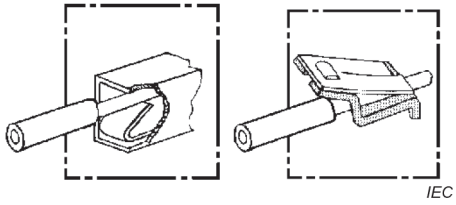

Figure 1d – Spring clamp connections, with a push-in spring clamp termination, with solid wires

Figure 1 – Examples of spring clamp connections

3.3
spring clamp terminal
terminal designed to accept a conductor for the purpose of establishing a spring clamp connection

SEE: Figure 2

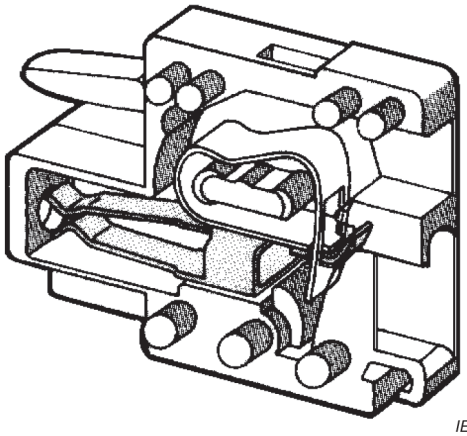

Figure 2 – Example of a spring clamp terminal

3.4
spring clamp connecting device
device for the electrical connection of one or more conductors comprising one or more spring clamp terminations and, if necessary, insulation and/or auxiliary parts

3.5
actuating element
part of a spring clamp termination or terminal to which an external force is to be applied, and the resulting movement of which provides a means for activating or deactivating the spring

4 Requirements

4.1 Workmanship

The connection shall be processed in a careful and workmanlike manner, in accordance with good current practice. Annex A (informative) provides practical guidance and may constitute a benchmark for the assessment of workmanship.

NOTE Some industry sectors (e.g. automotive, aerospace, marine, nuclear, military) use workmanship standards which can be considered upon agreement between manufacturer and user.

4.2 Tools

Tools, if necessary, shall be used and inspected according to the instructions given by the manufacturer.

5 Pre-requisites for basic test schedule

5.1 Spring clamp terminations

5.1.1 Materials

– Materials for the current-carrying parts:

suitable grades of copper or copper alloy shall be used.

– Materials for the spring clamp parts:

suitable (according to manufacturer's instructions) grades of copper alloy or steel shall be used.

5.1.2 Surface finishes

The contact area of the current-carrying parts shall be plated with tin or tin-alloy.

The surface shall be free of detrimental contamination or corrosion.

5.1.3 Design features

Spring clamp terminations shall be designed so that the spring clamp parts establish a force to connect the conductors which ensures that the necessary contact pressure is maintained.

In a spring clamp connecting device, each conductor shall be clamped individually.

The openings for use of a tool intended to assist the insertion or withdrawal of the conductor shall be clearly distinguishable from the conductor's entry hole.

5.1.4 Dimensions

The suitability of a spring clamp connection depends on the dimensions of the termination together with the characteristics of the materials used.

The dimensions of the termination shall be chosen so as to be suitable for (i.e. able to accept) the cross-sectional area of the conductor or the range of conductors for which the termination is designed.

The suitability is verified by applying the test schedules given in Clause 8.

5.2 Wires

5.2.1 General

Wires with solid, stranded and flexible conductors according to IEC 60228 or IEC 60189-3 shall be used depending on the type of spring clamp terminations.

5.2.2 Materials

The conductor used shall be made of annealed copper.

5.2.3 Dimensions

Wires with the following dimensions shall be used:

– solid wires of 0,32 mm to 3,7 mm nominal diameter (0,08 mm^2 to 10 mm^2 cross-section), or
– stranded wires of 0,08 mm^2 to 10 mm^2 cross-section, or
– flexible wires of 0,08 mm^2 to 10 mm^2 cross-section.

5.2.4 Surface finishes

The conductor shall be unplated or plated with tin or tin-alloy.

The conductor surface shall be free of contamination and corrosion which degrades performance.

5.2.5 Wire insulation

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

5.3 Spring clamp connections

a) The combination of conductor and spring clamp termination shall be compatible.

b) The wire shall be stripped to the correct length specified by the manufacturer. The stripped part of the wire shall not be damaged and shall be clean and free from particles of insulation.

c) The conductor shall be correctly located in the spring clamp termination at the correct depth specified by the manufacturer.

All strands of the wire shall be within the spring clamp termination.

6 Testing

6.1 General

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

a) spring clamp connections which conform to all the requirements of Clause 5 shall be tested in accordance with and meet the requirements of the basic test schedule, see 8.2;

b) spring clamp connections which do not fully conform to all the requirements of Clause 5, for example, those which are made with different wire types and/or termination sizes and/or materials, shall be tested and meet the requirements of the full test schedule given in 8.3.

6.2 Standard conditions for testing

Unless otherwise specified, all tests shall be carried out under 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 test conditions for referee measurements and tests set out in IEC 60068-1.

6.3 Preconditioning

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

6.4 Recovery

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.

6.5 Mounting of specimen

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

b) Each test specimen shall consist of one spring clamp connection prepared as required in the test schedules.

When more test specimens are required, they may be part of the same multipole spring clamp connecting devices.

7 Tests

7.1 General examination

The examination shall be carried out in accordance with Test 1a of IEC 60512-1-1, and Test 1b of IEC 60512-1-2. The visual examination test may be carried out with magnification up to approximately five times.

All spring clamp terminations and wires shall be examined to ensure that the applicable requirements of Clause 5 have been met.

7.2 Mechanical tests

7.2.1 Tensile strength

The test shall be carried out in accordance with Test 16t, method A, of IEC 60512-16-20.

Requirement:

The tensile strength of spring clamp connections shall be not less than specified in Table 1, unless otherwise specified by the detail specification.

Table 1 – Values of tensile strength

Conductor cross-section mm^2	Values of tensile strength N minimum
0,08 up to 0,22 (not included)	4
0,22	10
0,34	15
0,5	20
0,75	30
1,0	35
1,5	40
2,5	50
4,0	60
6,0	80
10,0	90

7.2.2 Wire deflection

NOTE This test method is similar to the deflection test method for screwless terminals described in IEC 60884-1.

Spring clamp terminations shall be so designed that the inserted solid conductor remains clamped, even when the conductor has been deflected during normal installation, for example, during mounting in a box, and the deflecting stress is transferred to the spring clamp termination.

Compliance is checked by the following test which is made on specimens which have not been used for any other test.

a) Test apparatus

The test apparatus, the principle of which is shown in Figure 3, shall be so constructed that:

– a specified conductor, properly inserted into a terminal, is allowed to be deflected in any of the 12 directions differing from each other by 30°, with a tolerance referred to each direction of ±5° and;

– the starting point can be varied by 10° and 20° from the original point.

A reference direction need not be specified.

The deflection of the conductor from its straight position to the testing positions shall be effected by means of a suitable device applying a specified force to the conductor at a certain distance from the terminal.

The deflecting device shall be so designed that:

– the force is applied in the direction perpendicular to the undeflected conductor;

– the deflection is attained without rotation or displacement of the conductor within the clamping unit, and

– the force remains applied whilst the prescribed voltage drop measurement is made.

Provisions shall be made so that the voltage drop across the spring clamp termination under test can be measured when the conductor is connected, as shown for example in Figure 3.

b) Test method

The specimen is mounted on the fixed part of the test apparatus in such a way that the specified conductor inserted into the spring clamp termination under test can be freely deflected.

The surface of the test conductor shall be free of detrimental contamination or corrosion.

NOTE If necessary, the inserted conductor can be permanently bent around obstacles, so that these do not influence the results of the test.

In some cases, with the exception of the case of guidance for the conductors, it may be advisable to remove those parts of the specimen which do not allow the deflection of the conductor corresponding to the force to be applied.

A spring clamp termination is fitted as for normal use with a solid copper conductor having the smallest cross-sectional area as specified by the manufacturer and is submitted to a first test sequence; unless the first test sequence has failed, the same spring clamp termination is submitted to a second test sequence using the conductor having the largest cross-sectional area.

The force for deflecting the conductor is specified in Table 2, the distance of 100 mm being measured from the extremity of the terminal, including the guidance for the conductor, if any, to the point of application of the force to the conductor.

The test is made with continuous current (i.e. the current is not switched on and off during the test); a suitable power supply should be used so that the current variations are kept within ±5 % during the test.

Table 2 – Value of force for wire deflection test

Cross-section of the test conductor mm^2	Force for deflecting the test conductors N
0,5 up to 0,75 (not included)	0,09
0,75	0,16
1,0	0,25
1,5	0,5
2,5	1,0
4	2,0
6	3,5
10	7,0
The forces are chosen so that they stress the conductors close to the limit of elasticity.	

c) Test procedure

A tenth of the test current assigned to the wire according to Table 4 is passed through the spring clamp connection under test. A force, according to Table 2, is applied to the test conductor inserted in the spring clamp termination under test in the direction of one of the 12 directions shown in Figure 3 and the voltage drop across this spring clamp connection is measured. The force is then removed.

The force is then applied successively in each of the remaining 11 directions shown in Figure 3 following the same test procedure.

If at any of the 12 test directions the voltage drop is greater than 2,5 mV, the force is kept applied in this direction until the voltage drop is reduced to a value below 2,5 mV, but for not more than 1 min. After the voltage drop has reached a value lower than or equal to 2,5 mV, the force is kept applied in the same direction for a further period of 30 s during which period the voltage drop shall not have increased.

The other specimens of the set are tested following the same test procedure, but moving the 12 directions of the force so that they differ by approximately 10° for each specimen. If one specimen of the set has failed at one of the directions of application of the test force, the tests are repeated on another set of specimens, all of which shall comply with the repeated tests.

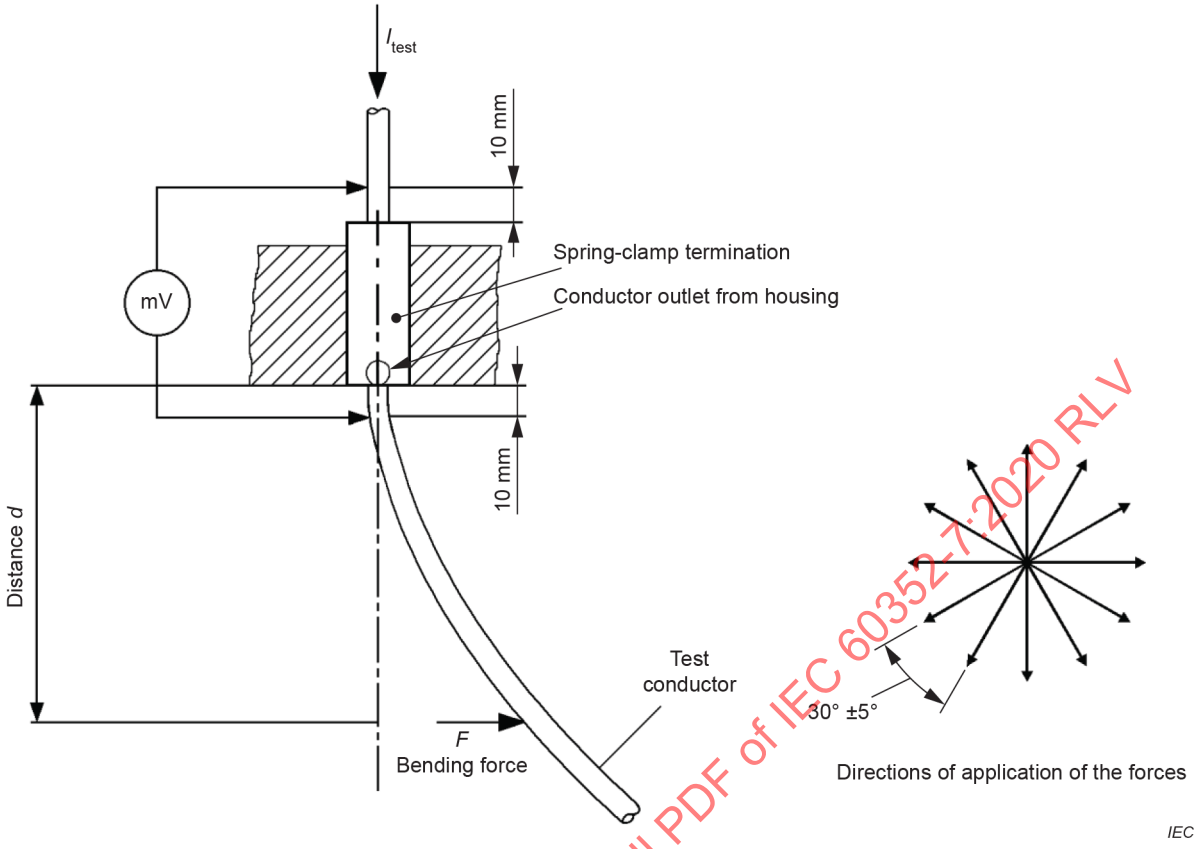

Figure 3 – Information for the wire deflection test

7.2.3 Vibration

The test shall be carried out in accordance with Test 6d of IEC 60512-6-4.

The component shall be firmly held on a vibration table.

An example of a suitable test arrangement for testing a component containing a spring clamp connection is shown in Figure 4. Contact disturbance shall be monitored during the vibration test in accordance with Test 2e of IEC 60512-2-5, see Table 3.

The limit of duration of contact disturbance shall be 1 µs unless otherwise specified by the detail specification.

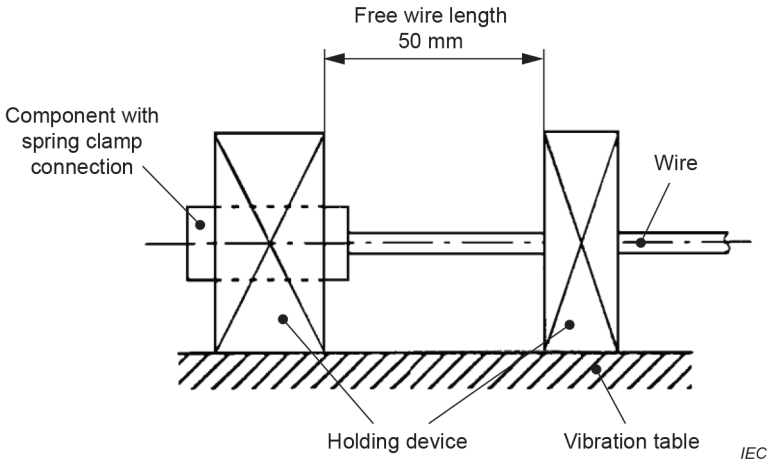

Figure 4 – Test arrangement, vibration

Table 3 – Vibration, test severities

Range of frequency, Hz	10 to 55	10 to 500	10 to 2 000
Overall duration, h	2,25	6	7,5
Displacement amplitude below the cross-over frequency, mm	0,35	0,35	1,5
Acceleration amplitude above the cross-over frequency, m/s^2	–	50	200
Directions	3 axes	3 axes	3 axes
Number of sweep cycles per direction	10	10	10

Unless otherwise specified, the test shall be carried out in the 10 Hz to 55 Hz range.

7.2.4 Repeated connections and disconnections

The object of this test is to assess the ability of a spring clamp termination with a wire range specified by the manufacturer to withstand a specified number of connections and disconnections.

If the termination is designed to accept a range of conductor sizes:

- for the smallest conductor
  - all cycles but the last one shall be carried out with the largest conductor size specified. The last cycle and the final measurement shall be carried out with the smallest conductor size specified.
- for the largest conductor
  - all cycles shall be carried out with the largest conductor size specified. The final measurement shall be carried out with the largest conductor size specified.

A stripped wire of the largest size specified shall be inserted into the spring clamp termination under test in the specified manner. After this, the conductor shall be extracted in the specified manner. This shall be considered as one test cycle.

The last of the specified number of test cycles consists of only inserting the unprepared stripped wire into the termination, so as to have a spring clamp connection at the end of the specified number of test cycles.

The same spring clamp termination shall be submitted to all the required number of test cycles.

A new part of the wire or a new wire of the same type shall be used for each test cycle.

Test severities:

The conductor cross-section for the last cycle and the number of cycles to be carried out shall be specified by the detail specification or by the manufacturer. Preferred values for the number of cycles are 4, 20 or 100.

7.3 Electrical tests

7.3.1 Contact resistance

The test shall be carried out in accordance with Test 2a of IEC 60512-2-1 or Test 2b of IEC 60512-2-2, as specified in the relevant specification.

A suitable test arrangement is shown in Figure 5.

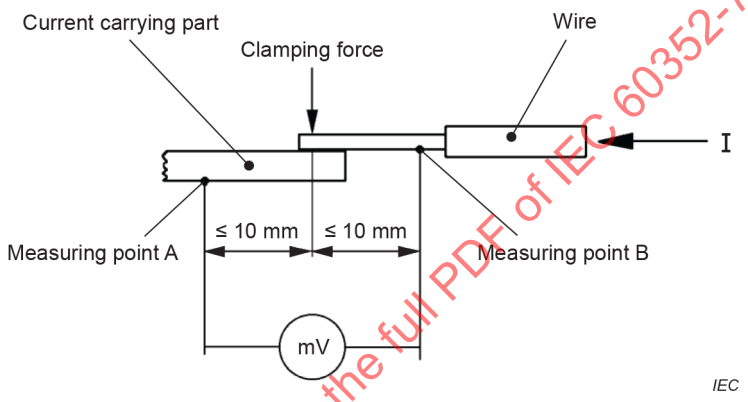

Figure 5 – Test arrangement, current method

Measuring point A shall be as close as possible to the end of the wire in the spring clamp connection but not touching the end of the conductor.

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

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

When Test 2b is applied, the test current shall be 1/10 of the rated current of the wire according to Table 4, unless otherwise specified by the detail specification.

The maximum contact resistance shall not exceed the lower of the following values:

– either the values of the maximum contact resistance of Table 4, or
– 2,5 times the initial values of the measurement.