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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 9-5: Endurance tests – Test 9e: Current loading, cyclic

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 60512-9-5 has been prepared by subcommittee 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 published in 2010. This edition constitutes a technical revision.

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

- added method B and renamed the former test method as method A, to provide an alternative with more adjustable time “ON” and “OFF” for products with larger thermal mass;
- added introduction to provide background of this revision;

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

FDIS	Report on voting
48B/2803/FDIS	48B/2819/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60512 series, published under the general title *Connectors for electrical and electronic equipment – Tests and measurements*, 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

The object of this document is to detail a standard method for subjecting solderless connections to a thermal stress conditioning by cyclic current loading, in order to verify the right combination of conductor material, termination material and tool application – if any is required, in view of any possible creep phenomena that might lead to a reduction of performance of the solderless connection.

Although requiring electric power to apply the specified current loading, this test is an endurance test by thermal conditioning, whose aim is to submit specimens of connectors using solderless connections or of solderless connections to a repeated cycling between ambient temperature (normal laboratory conditions) and the upper limiting temperature (ULT) specified for the connector or solderless connection, either by the detail product specification or the manufacturer specification, or by the default values provided in the relevant part of IEC 60352 series.

The way the solderless connection under test acts is affected both by the solderless termination design and material and the attached conductor size and material, as well as by any tool applied to produce the connection, with all relevant settings and accessories as specified for the particular combination of termination and conductor.

Time “ON” represents the “heating” interval necessary to reach the ULT from ambient temperature, time “OFF” represents the “cooling” interval, necessary to cool down the specimen to ambient temperature. The sum of these intervals represents a cycle. Due to the various nature of a solderless connection in terms of size and thermal inertia of the termination and of the attached conductor, the traditional method with fixed duty cycle duration it is not always suitable.

For this reason, two methods are now provided to perform this test:

– method A is the traditional one, with time “ON” of 45 min and time “OFF” of 15 min, that has proven suitable for small-sized solderless connections, e.g. connections employing conductors with cross-sectional area less than or equal to 10 mm^2. However, even in such cases, depending on the thermal mass of the termination or the conductor (e.g. for a crimped connection), method B may be preferable;

– method B is with time “ON” or time “OFF” to be determined experimentally by the first test cycle. Moreover, heating time by current load may be even abbreviated by increasing and controlling the current load, whereas cooling may be accelerated too, by forced air cooling. Because the number of repeated cycles is the primary factor affecting the severity of this test, long duration times at ULT (highest temperature) and ambient temperature (lowest temperature) may not be necessary for the purpose of this test. This method is suitable for large-sized solderless connections, e.g. connections employing conductors with cross-sectional area larger than 10 mm^2.

CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 9-5: Endurance tests – Test 9e: Current loading, cyclic

1 Scope ~~and object~~

This part of IEC 60512, when required by the detail product specification, is used for testing connectors or solderless connections within the scope of technical committee 48. It may also be used for similar devices when specified in a detail product specification.

The object of this document is to detail a standard method for subjecting solderless connections to thermal stress conditioning by cyclic current loading.

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 60352 (all parts), *Solderless connections*

IEC 60512-1:2018, *Connectors for electrical and electronic equipment – Tests and measurements – Part 1: ~~General~~ Generic specification*

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

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 60512-2-6, *Connectors for electronic equipment – Tests and measurements – Part 2-6: Electrical continuity and contact resistance tests – Test 2f: Housing (shell) electrical continuity*

IEC 60512-3-1, *Connectors for electronic equipment – Tests and measurements – Part 3-1: Insulation tests – Test 3a: Insulation resistance*

IEC 60512-4-1, *Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60512-1 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

4 Preparations

4.1 Test equipment

For the performance of this thermal conditioning, a suitable current source generator is required. Test may be performed either in AC or DC current. The output voltage of the power source shall be suitable to cover the voltage drop all along the test circuit, which may foresee daisy chained specimens (see 4.2 and 4.3).

Other instruments required are a voltmeter to measure voltage drop and a micro-ohm meter to measure resistance across the solderless connection under test.

Further test instruments are those specified in the relevant test methods called up in the following clauses.

4.2 Preparation of specimens

A specimen shall consist of a solderless connection made with the relevant termination and the appropriate conductor as specified in the detail product specification.

Type and number of specimens shall be specified in the detail product specification. In case of multiple specimens, these may be wired in series, provided that each specimen does not thermally influence the subsequent one. Therefore, the length of the connecting conductors shall be chosen long enough to avoid mutual influence (the temperature at the opposite end of a heated specimen should be ambient temperature).

4.3 Mounting of specimens

Mounting and electrical connections in the test circuit shall be as specified in the detail product specification, e.g. connection of several specimens in series.

For solderless connections used in connectors, in case of multiple specimens specified, the specimens shall be mounted inside one or more relevant connector mating pairs.

5 Test/measuring methods

5.1 Pre-conditioning

Before starting the initial measurements, the specimens shall be pre-conditioned under standard atmospheric conditions for testing as specified in IEC 60512-1 for a period of 24 h, unless otherwise specified in the detail product specification.

5.2 Initial measurements

Before test is started, initial measurements (e.g. initial contact resistance or initial voltage drop) as specified in the detail product specification shall be done in accordance with the relevant part of IEC 60512.

5.3 Test

5.3.1 General

Two methods are available:

– method A is the traditional one, fixing the time “ON” and time “OFF” of the cyclic current loading;
– method B is a variant of method A that identifies experimentally the time “ON” and “OFF” of the cyclic current loading during the first cycle of test, and allows forced heating and cooling, in order to reduce time, when a high number of cycles is specified, e.g. by increasing the applied current and then regulating it, and by using forced air cooling.

Method A is suitable for small-sized solderless connections, e.g. connections employing conductors with cross-sectional area lower than or equal to 10 mm^2. However, even in such cases, depending on the thermal mass of the termination (e.g. crimp contact), method B may be preferable.

Method B is suitable for large-sized solderless connections, e.g. connections employing conductors with cross-sectional area larger than 10 mm^2.

5.3.2 Method A

This method is particularly suitable for relatively small solderless connections. When the involved dimensions of both the solderless termination and the attached conductor, their mass, and the implied thermal mass are likely to determine longer heating and cooling periods, method B is preferable.

The test shall be carried out in still air.

The ambient temperature shall be recorded during the test. Care shall be taken to minimize radiant heat effects.

The specimen shall be loaded with current as specified in the detail product specification. The purpose of this current load is to increase the temperature of the specimens up to the ULT specified in the detail product specification or, in lack of it, the default ULT specified in the relevant part of IEC 60352.

Current loading shall be "ON" for 45 min and "OFF" for 15 min. This shall be considered to be one cycle. ~~The number of cycles shall be as specified in the detail specification.~~ Preferred numbers of cycles are 20, 100 and 500, unless otherwise specified in the detail product specification.

Material combinations which have proven their reliable performance in many years of application in multiple application-specific working conditions, do not require a high number of cycles specified. Material combinations that are new or different from those referred to as preferred choice in the relevant part of IEC 60352 shall require a high number of cycles to gain validation.

5.3.3 Method B

This method is particularly suitable for large-sized solderless connections, i.e. employing cross-sectional area conductors larger than 10 mm^2. This method can however be used also for smaller sized solderless connections.

The heating period and cooling period are not of specified duration. Their duration shall be established experimentally at the first cycle.

The current to apply for heating shall be such that the solderless connection reaches at regime (steady-state) the upper limiting temperature (ULT) specified by the detail product specification or by the relevant part of IEC 60352 (e.g. by default for crimped connection ULT = 125 °C).

The ambient temperature shall be recorded during the test.

When this test is applied on solderless connections to be used in connectors, this current is provided by the derating diagram of the connector, for the specified conductor cross-sectional area, where the solderless connection under test is used.

In such cases the specimens shall be arranged in the relevant connector mated pair(s) in a condition representative of their actual use.

All points of a derating curve represent combinations of current (derated by a factor 0,8 unless otherwise specified on the derating curve) and ambient temperature for which the connection's hot spot reaches the ULT.

It is allowed to shorten the heating and cooling periods of a cycle, in order to minimize overall test duration, e.g. by applying a current higher than that identified above and then regulating it during the heating period, and by using forced air cooling during the cooling period.

The regime (steady state) condition, both at the end of the heating and of the cooling periods, is reached when thermal stability is achieved. This is defined as when the temperature variation does not exceed 2 °C in 10 min (due to the amplitude of the temperature cycling, a more stringent accuracy in defining the steady state condition is not required).

The preferred numbers of cycles are 20, 100 and 500 unless otherwise specified in the detail product specification.

Material combinations that have proven their reliable performance in many years of application in multiple application-specific working conditions do not require a high number of cycles specified. Material combinations that are new or different from those referred to as preferred choice in the relevant part of the IEC 60352 series shall require a high number of cycles to gain validation.

5.4 Recovery

After this cyclic test and before carrying out any subsequent measurement, the specimen shall be allowed to recover at standard conditions for testing as specified in 6.1 of IEC 60512-1:2018 for a period of 1 h minimum.

5.5 Final measurements

a) Contact resistance (IEC 60512-2-1, test 2a). This test may be replaced by a voltage drop measurement (IEC 60512-2-2, test 2b), particularly suitable for large sized solderless connections. This is the first and most important failure criterion to fix in the detail product specification (or in the relevant part of IEC 60352).

b) Housing (shell) electrical continuity (IEC 60512-2-6, test 2f), where applicable.

c) Insulation resistance (IEC 60512-3-1, test 3a) , if applicable (solderless connections that do not have pre-insulated cover and that are tested outside of the connector body, do not require this test).

d) Voltage proof (IEC 60512-4-1, test 4a) , if applicable (solderless connections that do not have pre-insulated cover and that are tested outside of the connector body, do not require this test).

e) Visual examination (IEC 60512-1-1, test 1a).

f) Operational tests (if applicable, the detail product specification may e.g. require a sealing test from the IEC 60512-14 series, or an ingress protection test according IEC 60529).

~~NOTE If applicable, the detail specification may require a sealing test from the IEC 60512-14 series or an ingress protection test according IEC 60529.~~

6 Details to be specified

When this test is required by the detail product specification, the following details shall be specified:

a) type and number of specimens;

b) wire/conductor size, type and length;

c) mounting and electrical connections in the test circuit;

d) test method (method A or B);

e) initial measurements as applicable,and requirements after initial measurements (e.g. contact resistance or voltage drop, temperature rise, etc.);

f) test current to be applied;

g) upper limiting temperature for the solderless connection to reach at the end of the “heating” period;

h) number of cycles to be carried out;

i) final measurements as applicable, and requirements after final measurements (e.g. contact resistance or voltage drop, temperature rise, insulation resistance, etc., and operational tests);

j) any deviation from the standard test method.

Bibliography

IEC 60352-1:1997, *Solderless connections – Part 1: Wrapped connections – General requirements, test methods and practical guidance*

IEC 60352-2:2006, *Solderless connections – Part 2: Crimped connections – General requirements, test methods and practical guidance*
IEC 60352-2:2006/AMD1:2013

IEC 60352-3:1993, *Solderless connections – Part 3: Solderless accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-4:1994, *Solderless connections – Part 4: Solderless non-accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-5:2012, *Solderless connections – Part 5: Press-in connections – General requirements, test methods and practical guidance*

IEC 60352-6:1997, *Solderless connections – Part 6: Insulation piercing connections – General requirements, test methods and practical guidance*

IEC 60352-7:2002, *Solderless connections – Part 7: Spring clamp connections – General requirements, test methods and practical guidance*

IEC 60352-8:2011, *Solderless connections – Part 8: Compression mount connections – General requirements, test methods and practical guidance*

IEC 60512-14-2:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-2: Sealing tests – Test 14b: Sealing – Fine air leakage*

IEC 60512-14-4:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-4: Sealing tests – Test 14d: Immersion – Waterproof*

IEC 60512-14-5:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-5: Sealing tests – Test 14e: Immersion at low air pressure*

IEC 60512-14-6:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-6: Sealing tests – Test 14f: Interfacial sealing*

IEC 60512-14-7:1997, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 14: Sealing tests – Section 7: Test 14g: Impacting water*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

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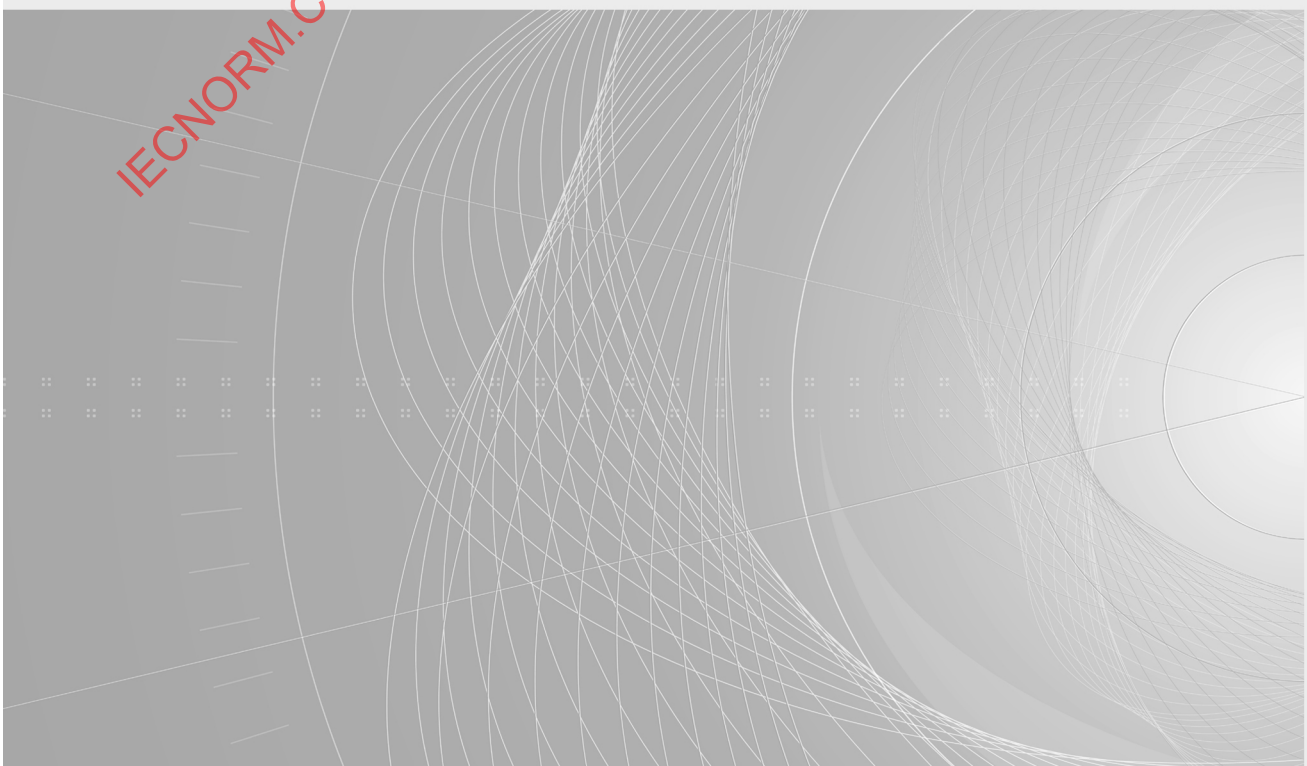
INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Connecteurs pour équipements électriques et électroniques – Essais et mesures – Partie 9-5: Essais d'endurance – Essai 9e: Charge en courant, essai cyclique



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CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 9-5: Endurance tests – Test 9e: Current loading, cyclic

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INTRODUCTION

The object of this document is to detail a standard method for subjecting solderless connections to a thermal stress conditioning by cyclic current loading, in order to verify the right combination of conductor material, termination material and tool application – if any is required, in view of any possible creep phenomena that might lead to a reduction of performance of the solderless connection.

Although requiring electric power to apply the specified current loading, this test is an endurance test by thermal conditioning, whose aim is to submit specimens of connectors using solderless connections or of solderless connections to a repeated cycling between ambient temperature (normal laboratory conditions) and the upper limiting temperature (ULT) specified for the connector or solderless connection, either by the detail product specification or the manufacturer specification, or by the default values provided in the relevant part of IEC 60352 series.

The way the solderless connection under test acts is affected both by the solderless termination design and material and the attached conductor size and material, as well as by any tool applied to produce the connection, with all relevant settings and accessories as specified for the particular combination of termination and conductor.

Time “ON” represents the “heating” interval necessary to reach the ULT from ambient temperature, time “OFF” represents the “cooling” interval, necessary to cool down the specimen to ambient temperature. The sum of these intervals represents a cycle. Due to the various nature of a solderless connection in terms of size and thermal inertia of the termination and of the attached conductor, the traditional method with fixed duty cycle duration it is not always suitable.

For this reason, two methods are now provided to perform this test:

– method A is the traditional one, with time “ON” of 45 min and time “OFF” of 15 min, that has proven suitable for small-sized solderless connections, e.g. connections employing conductors with cross-sectional area less than or equal to 10 mm^2. However, even in such cases, depending on the thermal mass of the termination or the conductor (e.g. for a crimped connection), method B may be preferable;

– method B is with time “ON” or time “OFF” to be determined experimentally by the first test cycle. Moreover, heating time by current load may be even abbreviated by increasing and controlling the current load, whereas cooling may be accelerated too, by forced air cooling. Because the number of repeated cycles is the primary factor affecting the severity of this test, long duration times at ULT (highest temperature) and ambient temperature (lowest temperature) may not be necessary for the purpose of this test. This method is suitable for large-sized solderless connections, e.g. connections employing conductors with cross-sectional area larger than 10 mm^2.

CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 9-5: Endurance tests – Test 9e: Current loading, cyclic

1 Scope

This part of IEC 60512, when required by the detail product specification, is used for testing connectors or solderless connections within the scope of technical committee 48. It may also be used for similar devices when specified in a detail product specification.

The object of this document is to detail a standard method for subjecting solderless connections to thermal stress conditioning by cyclic current loading.

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IEC 60512-1:2018, *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 60512-2-1, *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 60512-2-6, *Connectors for electronic equipment – Tests and measurements – Part 2-6: Electrical continuity and contact resistance tests – Test 2f: Housing (shell) electrical continuity*

IEC 60512-3-1, *Connectors for electronic equipment – Tests and measurements – Part 3-1: Insulation tests – Test 3a: Insulation resistance*

IEC 60512-4-1, *Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60512-1 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

4 Preparations

4.1 Test equipment

For the performance of this thermal conditioning, a suitable current source generator is required. Test may be performed either in AC or DC current. The output voltage of the power source shall be suitable to cover the voltage drop all along the test circuit, which may foresee daisy chained specimens (see 4.2 and 4.3).

Other instruments required are a voltmeter to measure voltage drop and a micro-ohm meter to measure resistance across the solderless connection under test.

Further test instruments are those specified in the relevant test methods called up in the following clauses.

4.2 Preparation of specimens

A specimen shall consist of a solderless connection made with the relevant termination and the appropriate conductor as specified in the detail product specification.

Type and number of specimens shall be specified in the detail product specification. In case of multiple specimens, these may be wired in series, provided that each specimen does not thermally influence the subsequent one. Therefore, the length of the connecting conductors shall be chosen long enough to avoid mutual influence (the temperature at the opposite end of a heated specimen should be ambient temperature).

4.3 Mounting of specimens

Mounting and electrical connections in the test circuit shall be as specified in the detail product specification, e.g. connection of several specimens in series.

For solderless connections used in connectors, in case of multiple specimens specified, the specimens shall be mounted inside one or more relevant connector mating pairs.

5 Test/measuring methods

5.1 Pre-conditioning

Before starting the initial measurements, the specimens shall be pre-conditioned under standard atmospheric conditions for testing as specified in IEC 60512-1 for a period of 24 h, unless otherwise specified in the detail product specification.

5.2 Initial measurements

Before test is started, initial measurements (e.g. initial contact resistance or initial voltage drop) as specified in the detail product specification shall be done in accordance with the relevant part of IEC 60512.

5.3 Test

5.3.1 General

Two methods are available:

– method A is the traditional one, fixing the time “ON” and time “OFF” of the cyclic current loading;
– method B is a variant of method A that identifies experimentally the time “ON” and “OFF” of the cyclic current loading during the first cycle of test, and allows forced heating and cooling, in order to reduce time, when a high number of cycles is specified, e.g. by increasing the applied current and then regulating it, and by using forced air cooling.

Method A is suitable for small-sized solderless connections, e.g. connections employing conductors with cross-sectional area lower than or equal to 10 mm^2. However, even in such cases, depending on the thermal mass of the termination (e.g. crimp contact), method B may be preferable.

Method B is suitable for large-sized solderless connections, e.g. connections employing conductors with cross-sectional area larger than 10 mm^2.

5.3.2 Method A

This method is particularly suitable for relatively small solderless connections. When the involved dimensions of both the solderless termination and the attached conductor, their mass, and the implied thermal mass are likely to determine longer heating and cooling periods, method B is preferable.

The test shall be carried out in still air.

The ambient temperature shall be recorded during the test. Care shall be taken to minimize radiant heat effects.

The specimen shall be loaded with current as specified in the detail product specification. The purpose of this current load is to increase the temperature of the specimens up to the ULT specified in the detail product specification or, in lack of it, the default ULT specified in the relevant part of IEC 60352.

Current loading shall be “ON” for 45 min and “OFF” for 15 min. This shall be considered to be one cycle. Preferred number of cycles are 20, 100 and 500, unless otherwise specified in the detail product specification.

Material combinations which have proven their reliable performance in many years of application in multiple application-specific working conditions, do not require a high number of cycles specified. Material combinations that are new or different from those referred to as preferred choice in the relevant part of IEC 60352 shall require a high number of cycles to gain validation.

5.3.3 Method B

This method is particularly suitable for large-sized solderless connections, i.e. employing cross-sectional area conductors larger than 10 mm^2. This method can however be used also for smaller sized solderless connections.

The heating period and cooling period are not of specified duration. Their duration shall be established experimentally at the first cycle.

The current to apply for heating shall be such that the solderless connection reaches at regime (steady-state) the upper limiting temperature (ULT) specified by the detail product

specification or by the relevant part of IEC 60352 (e.g. by default for crimped connection ULT = 125 °C).

The ambient temperature shall be recorded during the test.

When this test is applied on solderless connections to be used in connectors, this current is provided by the derating diagram of the connector, for the specified conductor cross-sectional area, where the solderless connection under test is used.

In such cases the specimens shall be arranged in the relevant connector mated pair(s) in a condition representative of their actual use.

All points of a derating curve represent combinations of current (derated by a factor 0,8 unless otherwise specified on the derating curve) and ambient temperature for which the connection's hot spot reaches the ULT.

It is allowed to shorten the heating and cooling periods of a cycle, in order to minimize overall test duration, e.g. by applying a current higher than that identified above and then regulating it during the heating period, and by using forced air cooling during the cooling period.

The regime (steady state) condition, both at the end of the heating and of the cooling periods, is reached when thermal stability is achieved. This is defined as when the temperature variation does not exceed 2 °C in 10 min (due to the amplitude of the temperature cycling, a more stringent accuracy in defining the steady state condition is not required).

The preferred numbers of cycles are 20, 100 and 500 unless otherwise specified in the detail product specification.

Material combinations that have proven their reliable performance in many years of application in multiple application-specific working conditions do not require a high number of cycles specified. Material combinations that are new or different from those referred to as preferred choice in the relevant part of the IEC 60352 series shall require a high number of cycles to gain validation.

5.4 Recovery

After this cyclic test and before carrying out any subsequent measurement, the specimen shall be allowed to recover at standard conditions for testing as specified in 6.1 of IEC 60512-1:2018 for a period of 1 h minimum.

5.5 Final measurements

a) Contact resistance (IEC 60512-2-1, test 2a). This test may be replaced by a voltage drop measurement (IEC 60512-2-2, test 2b), particularly suitable for large sized solderless connections. This is the first and most important failure criterion to fix in the detail product specification (or in the relevant part of IEC 60352).

b) Housing (shell) electrical continuity (IEC 60512-2-6, test 2f), where applicable.

c) Insulation resistance (IEC 60512-3-1, test 3a), if applicable (solderless connections that do not have pre-insulated cover and that are tested outside of the connector body, do not require this test).

d) Voltage proof (IEC 60512-4-1, test 4a), if applicable (solderless connections that do not have pre-insulated cover and that are tested outside of the connector body, do not require this test).

e) Visual examination (IEC 60512-1-1, test 1a).

f) Operational tests (if applicable, the detail product specification may e.g. require a sealing test from the IEC 60512-14 series, or an ingress protection test according IEC 60529).

6 Details to be specified

When this test is required by the detail product specification, the following details shall be specified:

a) type and number of specimens;

b) wire/conductor size, type and length;

c) mounting and electrical connections in the test circuit;

d) test method (method A or B);

e) initial measurements as applicable, and requirements after initial measurements (e.g. contact resistance or voltage drop, temperature rise, etc.);

f) test current to be applied;

g) upper limiting temperature for the solderless connection to reach at the end of the “heating” period;

h) number of cycles to be carried out;

i) final measurements as applicable, and requirements after final measurements (e.g. contact resistance or voltage drop, temperature rise, insulation resistance, etc., and operational tests);

j) any deviation from the standard test method.

Bibliography

IEC 60352-1:1997, *Solderless connections – Part 1: Wrapped connections – General requirements, test methods and practical guidance*

IEC 60352-2:2006, *Solderless connections – Part 2: Crimped connections – General requirements, test methods and practical guidance*
IEC 60352-2:2006/AMD1:2013

IEC 60352-3:1993, *Solderless connections – Part 3: Solderless accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-4:1994, *Solderless connections – Part 4: Solderless non-accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-5:2012, *Solderless connections – Part 5: Press-in connections – General requirements, test methods and practical guidance*

IEC 60352-6:1997, *Solderless connections – Part 6: Insulation piercing connections – General requirements, test methods and practical guidance*

IEC 60352-7:2002, *Solderless connections – Part 7: Spring clamp connections – General requirements, test methods and practical guidance*

IEC 60352-8:2011, *Solderless connections – Part 8: Compression mount connections – General requirements, test methods and practical guidance*

IEC 60512-14-2:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-2: Sealing tests – Test 14b: Sealing – Fine air leakage*

IEC 60512-14-4:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-4: Sealing tests – Test 14d: Immersion – Waterproof*

IEC 60512-14-5:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-5: Sealing tests – Test 14e: Immersion at low air pressure*

IEC 60512-14-6:2006, *Connectors for electronic equipment – Tests and measurements – Part 14-6: Sealing tests – Test 14f: Interfacial sealing*

IEC 60512-14-7:1997, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 14: Sealing tests – Section 7: Test 14g: Impacting water*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONNECTEURS POUR ÉQUIPEMENTS ÉLECTRIQUES ET ÉLECTRONIQUES – ESSAIS ET MESURES –

Partie 9-5: Essais d'endurance – Essai 9e: Charge en courant, essai cyclique

AVANT-PROPOS

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La Norme internationale IEC 60512-9-5 a été établie par le sous-comité 48B: Connecteurs électriques, du comité d'études 48 de l'IEC: Connecteurs électriques et structures mécaniques pour les équipements électriques et électroniques.

Cette deuxième édition annule et remplace la première édition, parue en 2010, dont elle constitue une révision technique.

La présente édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- introduction de la méthode B pour fournir une alternative avec des durées d'activation et de désactivation ajustables pour les produits de masse thermique plus élevée. L'ancienne méthode devient la méthode A;
- ajout d'une introduction pour présenter cette révision;

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
48B/2803/FDIS	48B/2819/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60512, publiées sous le titre général *Connecteurs pour équipements électriques et électroniques – Essais et mesures,* peut être consultée sur le site web de l'IEC.

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- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Le présent document a pour objet de définir une méthode normalisée pour soumettre des connexions sans soudure à une contrainte thermique appliquée au moyen d'une charge en courant de façon cyclique afin de vérifier la bonne combinaison de matériaux pour les conducteurs, de matériaux pour les sorties et d'outils, si des outils sont exigés pour l'application, afin de tenir compte d'un possible phénomène de fluage qui pourrait entraîner une diminution des performances de la connexion sans soudure.

Bien que de l'énergie électrique soit exigée pour appliquer la charge en courant spécifiée, cet essai est un essai d'endurance par conditionnement thermique, dont le but est de soumettre des spécimens de connecteurs utilisant des connexions sans soudure ou des spécimens de connexions sans soudure à des cycles répétés de températures allant de la température ambiante (conditions normales de laboratoire) à la température limite supérieure (ULT: *Upper Limiting Temperature*) spécifiées pour le connecteur ou la connexion sans soudure, soit dans la spécification particulière de produit, soit dans la spécification du fabricant, soit par les valeurs par défaut indiquées dans la partie applicable de la série IEC 60352.

Le comportement d'une connexion sans soudure en essai est affecté à la fois par la conception et le matériau des sorties sans soudure et par la taille et le matériau du conducteur attaché, mais aussi par n'importe quel outil utilisé pour réaliser la connexion, avec tous les réglages et accessoires applicables spécifiés pour la combinaison particulière de sortie et de conducteur.

La durée d'activation représente les intervalles de "chauffage" nécessaires pour atteindre la température limite supérieure depuis la température ambiante et la durée de désactivation représente les intervalles de "refroidissement" nécessaires pour refroidir le spécimen jusqu'à la température ambiante. La somme de ces intervalles représente un cycle. En raison des natures variées des connexions sans soudure en termes de taille et d'inertie thermique de la sortie et du conducteur attaché, la méthode traditionnelle avec une durée fixe de cycle de service n'est pas toujours appropriée.

Pour cette raison, deux méthodes sont maintenant prévues pour réaliser cet essai:

– la méthode A est la méthode traditionnelle, avec une durée d'activation de 45 min et une durée de désactivation de 15 min. Elle s'est montrée appropriée pour les connexions sans soudure de petite taille, par exemple des connexions utilisant des conducteurs dont l'aire de la section est inférieure ou égale à 10 mm^2. Toutefois, même dans ce cas, en fonction de la masse thermique de la sortie ou du conducteur (par exemple pour une connexion sertie), la méthode B peut être la méthode préférentielle;

– la méthode B est la méthode dans laquelle les durées d'activation et de désactivation sont à déterminer expérimentalement par le premier cycle d'essai. En outre, le temps de chauffage par charge en courant peut être réduit en augmentant et en contrôlant la charge en courant, et le temps de refroidissement peut être réduit en appliquant une ventilation forcée. Puisque le nombre de cycles répétés est le principal facteur affectant la sévérité de cet essai, de longues durées à la température limite supérieure (température la plus élevée) et à la température ambiante (température la plus faible) peuvent ne pas être nécessaires dans le cadre de cet essai. Cette méthode convient aux connexions sans soudure de grande taille, par exemple les connexions utilisant des conducteurs dont l'aire de la section est supérieure à 10 mm^2.

CONNECTEURS POUR ÉQUIPEMENTS ÉLECTRIQUES ET ÉLECTRONIQUES – ESSAIS ET MESURES –

Partie 9-5: Essais d'endurance – Essai 9e: Charge en courant, essai cyclique

1 Domaine d'application

La présente partie de l'IEC 60512 est utilisée pour les essais des connecteurs ou des connexions sans soudure du domaine d'activité du comité d'études 48, lorsque la spécification particulière de produit l'exige. Elle peut également être utilisée pour des dispositifs similaires lorsqu'une spécification particulière de produit l'indique.

L'objet du présent document est de définir une méthode normalisée pour soumettre les connexions sans soudure à une contrainte thermique appliquée au moyen d'une charge en courant de façon cyclique.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60352 (toutes les parties), *Connexions sans soudure*

IEC 60512-1:2018, *Connecteurs pour équipements électriques et électroniques – Essais et mesures – Partie 1: Spécification générique*

IEC 60512-1-1, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 1-1: Examen général – Essai 1a: Examen visuel*

IEC 60512-2-1, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 2-1: Essais de continuité électrique et de résistance de contact – Essai 2a: Résistance de contact – Méthode du niveau des millivolts*

IEC 60512-2-2, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 2-2: Essais de continuité électrique et de résistance de contact – Essai 2b: Résistance de contact – Méthode du courant d'essai spécifié*

IEC 60512-2-6, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 2-6: Essais de continuité électrique et de résistance de contact – Essai 2f: Continuité électrique du boîtier (coquille)*

IEC 60512-3-1, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 3-1: Essais d'isolement – Essai 3a: Résistance d'isolement*

IEC 60512-4-1, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 4-1: Essais de contrainte diélectrique – Essai 4a: Tension de tenue*