



UL 486A-486B

Underwriters Laboratories Inc. Standard for Safety

Wire Connectors



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Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Wire Connectors, UL 486A-486B

First Edition, Dated November 15, 2003

Revisions: This Standard contains revisions through and including April 9, 2009.

Summary of Topics

This revision of ANSI/UL 486A-486B includes the following changes:

Addition of requirements for copper-clad aluminum conductor connectors included as an Adoption bulletin attached to the back of the standard.

These requirements dated April 9, 2009 have been processed in accordance with UL's ANSI accredited procedures. These requirements have not yet been processed by the other Standards Development Organizations associated with this harmonized standard. Accordingly, these adopted requirements and related effective date information appear at the back of the UL version only. UL will be working with the other SDOs to process these requirements through the full harmonization development process in the near future.

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

Adoption Bulletin(s): This Standard contains the adoption bulletin(s) dated April 9, 2009. The adoption bulletin is located at the end of the Standard.

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated December 19, 2008.

The revisions dated April 9, 2009 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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This Standard consists of pages dated as shown in the following checklist:

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First Edition

Wire Connectors

November 15, 2003

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ANSI/UL 486A-486B-2009

Approved
by
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of Canada



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Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA, or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA, and UL. CSA and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA and UL pages.

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This ANSI/UL Standard for Safety consists of the First Edition including revisions through April 9, 2009.

The most recent designation of ANSI/UL 486A-486B as an American National Standard (ANSI) occurred on April 9, 2009. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

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ANNEX E – Marking Locations Guide

Preface

This is the common ANCE, CSA, and UL standard for *Wire Connectors*. It is the second edition of NMX-J-543-ANCE, the fourth edition of C22.2 No. 65, and the first edition of UL 486A-486B. This edition of CSA C22.2 No. 65 supersedes the previous edition published in 1993.

This common standard was prepared by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc., (UL). The efforts and support of the Technical Harmonization Committee for Connectors, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard was reviewed by the CSA Subcommittee on C22.2 No. 65, under the jurisdiction of the CSA Technical Committee on Wiring Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard will be submitted to the Standards Council of Canada (SCC) for approval as a National Standard of Canada.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

A UL standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The Technical Harmonization Committee identified several IEC standards that address electrical wire connectors included in the scope of this standard. The IEC standards for electrical wire connectors are recognized as being generally system specific, containing the requirements for the relevant wire connectors and cables in many discrete IEC standards.

The THC determined the safe use of electrical wire connectors is dependent on the design and performance of the wire connectors in relation to the North American Electrical Codes with which they are intended to be installed. The THC agreed such future investigation will be facilitated by the harmonization of the North American Electrical Codes for wire connectors with IEC installation practices.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

ANCE Effective Date

The effective date for ANCE will be announced through the Diario Oficial de la Federación (Official Gazette) and is indicated on the cover page.

CSA Effective Date

The effective date for CSA International will be announced through CSA Informs or a CSA certification notice.

UL Effective Date

As of August 25, 2006 all products Listed or Recognized by UL must comply with the requirements in this standard except for clauses in the following list, which are effective October 10, 2006.

Clauses 6.2.5, 6.2.6, 10.42

A UL effective date is one established by Underwriters Laboratories Inc. and is not part of the ANSI approved standard.

Foreword (ANCE)

The present Mexican Standard was developed by the Low Voltage Wires and Cables Subcommittee from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of wire and cable manufacturers and users.

ANCE is an Organization for Standardization (ONN) registered by the DGN (Dirección General de Normas) in the electrical sector and household appliances. ANCE develops Mexican Standards (NMX) and collaborates in the development of the Mexican Official Standards (NOM); these are voluntary and normative standards, respectively.

Conformity assessment in accordance with ANCE Mexican Standards is the responsibility of ANCE's Product Certification Division.

ANCE's Product Certification Division is accredited by the EMA (Entidad Mexicana de Acreditación) to certify a variety of products. Certification is carried out following the relevant procedures established and developed by the Technical Committee on Certification in connection with the test reports produced in test labs accredited by the EMA.

The conformity assessment activities developed by ANCE cover quality systems, test labs, and product verification.

Foreword (CSA)

The Canadian Standards Association (CSA) develops standards under the name Canadian Standards Association, and provides certification and testing under the name CSA International. CSA International provides certification services for manufacturers who, under license from CSA, wish to use the appropriate registered CSA Marks on certain products of their manufacture to indicate conformity with CSA Standards.

CSA Certification for a number of products is provided in the interest of maintaining agreed-upon standards of quality, performance, interchangeability and/or safety, as appropriate. Where applicable, certification may form the basis for acceptance by inspection authorities responsible for enforcement of regulations. Where feasible, programs will be developed for additional products for which certification is desired by producers, consumers, or other interests. In performing its functions in accordance with its objectives, CSA does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of the Association represent its professional judgement given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed.

Products in substantial accord with this Standard but which exhibit a minor difference or a new feature may be deemed to meet the Standard providing the feature or difference is found acceptable utilizing appropriate CSA International Operating Procedures. Products that comply with this Standard shall not be certified if they are found to have additional features which are inconsistent with the intent of this Standard. Products shall not be certifiable if they are discovered to contravene applicable laws or regulations.

Testing techniques, test procedures, and instrumentation frequently must be prescribed by CSA International in addition to the technical requirements contained in Standards of CSA. In addition to markings specified in the Standard, CSA International may require special cautions, markings, and instructions that are not specified by the Standard.

Some tests required by CSA Standards may be inherently hazardous. The Association neither assumes nor accepts any responsibility for any injury or damage that may occur during or as the result of tests, wherever performed, whether performed in whole or in part by the manufacturer or the Association, and whether or not any equipment, facility, or personnel for or in connection with the test is furnished by the manufacturer or the Association.

Manufacturers should note that, in the event of the failure of CSA International to resolve an issue arising from the interpretation of requirements, there is an appeal procedure: the complainant should submit the matter, in writing, to the Secretary of the Canadian Standards Association.

If this Standard is to be used in obtaining CSA Certification please remember, when making application for certification, to request all current Amendments, Bulletins, Notices, and Technical Information Letters that may be applicable and for which there may be a nominal charge. For such information or for further information concerning CSA Certification, please address your inquiry to Applications and Customer Service, CSA International, 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3.

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Foreword (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

1 Scope

1.1 This Standard applies to connectors for use with all alloys of copper or aluminum conductors, or both, for providing contacts between current-carrying parts, in accordance with the Canadian Electrical Code, Part I, C22.1, in Canada, the National Electrical Code, NFPA-70, in the United States of America, or the Standard for Electrical Installations, NOM-001-SEDE, in Mexico, as follows:

- a) pressure wire connectors intended to hold one or more conductor(s);
- b) connectors intended for use in appliances and equipment that comply with the requirements for such appliances and equipment;
- c) soldering connectors;
- d) splicing wire connectors intended for use with 4 AWG (21.2 mm²) or larger conductors;

Note: A splicing wire and cable connector taking a range of conductor sizes may include conductor sizes smaller than 4 AWG (21.2 mm²).

- e) neutral bars;
- f) uninsulated connectors that are used in circuits rated 35 000 V and below;
- g) ampere-rated connectors not intended for general use; and
- h) insulation piercing connectors.

1.2 This Standard is intended for connectors suitable for use with conductors in the size ranges as follows:

a) Aluminum

- 1) 12 AWG (3.3 mm²) and 10 AWG (5.3 mm²) solid; and
- 2) 12 AWG (3.3 mm²) to 2 000 kcmil (1 010 mm²) stranded, Class B concentric, compressed, and unidirectional lay compact.

b) Copper

- 1) 30 AWG (0.05 mm²) to 10 AWG (5.3 mm²) solid; and
- 2) 30 AWG (0.05 mm²) to 2 000 kcmil (1 010 mm²) stranded, Class B concentric and compressed, and Class C concentric.

c) Compact-stranded copper conductors

- 1) in Canada for 8 AWG (8.4 mm²) and larger;
- 2) in the United States for 2 AWG (33.6 mm²) and larger; and
- 3) in Mexico for 8 AWG (8.4 mm²) and larger.

d) Rigid (solid and stranded) metric wire falling within the ranges of the above AWG sizes.

Note: For example, a connector rated for 6 AWG – 250 kcmil may be additionally rated for 16 – 120 mm².

e) Other class and strand configurations as indicated by marking.

1.3 This Standard is intended for connectors suitable for currents not exceeding the ampacity of insulated conductors rated 75°C or 90°C in accordance with the connector rating of the connector, if provided.

1.4 In the United States and Mexico, these requirements cover insulated connectors, insulating caps, and covers intended for use at 600 volts or less (1 000 volts in a sign or luminaire) and uninsulated connectors for use in general use circuits rated 2 000 volts nominal or less.

In Canada, these requirements cover insulated connectors, insulating caps, and covers intended for use at 600 volts or less (1 000 volts in a sign or luminaire) and uninsulated connectors for circuits rated 2 000 volts phase-to-phase or less. Uninsulated connectors may also be used in applications up to 5 000 volts phase-to-phase where allowed and installed in accordance with Section 36 of the Canadian Electrical Code, Part I, C22.1.

1.5 This standard also applies to uninsulated connectors (both terminal and splicing types) for use in circuits rated 35 000 volts or less.

1.6 This Standard does not apply to:

- a) connectors intended for direct burial;
- b) insulated connectors for voltage levels above 600 V (1 000 V in a sign, lighting fixture, or luminaire);
- c) manual twist-on connectors;
- d) built-in terminal connectors in devices rated less than 30 A intended for outlet box mounting or having provision for stress relief;
- e) flat quick connect terminals; and
- f) wire binding screw terminals.

2 Reference Publications

2.1 Normative references

2.1.1 For undated references to Standards, such reference shall be considered to refer to the latest edition and all revisions to that edition up to the time when this Standard was approved. For dated references to Standards, such reference shall be considered to refer to the dated edition and all revisions published to that edition up to the time the Standard was approved.

2.1.2 ANCE Standards

NMX-J-508-ANCE

Electrical Features – Safety Requirements – Specifications and Test Methods

2.1.3 CSA Standards

C22.1-02

Canadian Electrical Code, Part I (CEC)

CAN/CSA-C22.2 No. 0.17-00

Evaluation of Properties of Polymeric Materials

2.1.4 UL Standards

UL 94

Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 746C

Polymeric Materials – Use in Electrical Equipment Evaluations

2.1.5 NFPA* Standard

ANSI/NFPA 70-2005,

National Electrical Code (NEC)

*National Fire Protection Association

2.1.6 NOM Standards – Mexican Secretary of Energy

NOM-001-SEDE,

Standard for Electrical Installations

2.2 Informative references

2.2.1 See Annex A for a listing of supplemental standards.

3 Units of Measurement

3.1 The values given in SI (metric) units shall be normative, except for AWG/kcmil conductor sizes. Any other values are for information only.

4 Definitions

4.1 For the purpose of this Standard, the following terms and definitions apply.

4.2 circular mil (cmil) – the area of a circle with a diameter of 0.001 inch.

4.3 connector – device for connecting a conductor to an equipment terminal or for connecting two or more conductors to each other.

4.4 control conductor – an unbroken conductor, which is included in the current-cycling test loop.

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

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

4.6 equalizer – a busbar that provides a point of equipotential and uniform current flow in a stranded conductor without adversely affecting the temperature of the connector(s).

4.7 packaging container – the container in which the unit containers are packaged.

4.8 rated current (ampere rating) – current assigned to the connector by the manufacturer.

4.9 splicing wire connector – establishes a connection between two or more conductors by means of mechanical pressure and is not intended to be permanently mounted.

4.10 stability factor S – the measure of temperature stability of a connector during the current-cycling test.

4.11 temperature rating – the maximum temperature of an insulated connector, assigned by the manufacturer.

4.12 temperature rise – denotes the difference of the temperature of the connector, measured under load, and the ambient temperature.

4.13 terminal connector – establishes a connection between one or more conductors to a terminal plate or stud, or to any similar device, by means of mechanical pressure.

4.14 unit container – the smallest container in which connectors are packaged.

4.15 voltage rating – the maximum voltage of an insulated connector.

5 Symbols and Abbreviations

5.1 ° – Degree

5.2 A – Amps, Amperes

5.3 Al – Aluminum

5.4 AWG – American Wire Gage/gauge

5.5 C – Celsius

5.6 Cu – Copper

5.7 d – Days

5.8 f – Flexible

5.9 h – Hours

5.10 HgNO_3 – Mercurous nitrate

5.11 Hz – Hertz, cycles per second

5.12 in – Inch, Inches

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5.13 kcmil – Thousand circular mil

5.14 m – Meter

5.15 mil – Thousandth of an inch

5.16 min – Minutes

5.17 ml – Milliliter

5.18 mm – Millimeter

5.19 mm² – Square millimeter

5.20 N – Newton – kilogram meter/sec²

5.21 NH₄ – Ammonia

5.22 r – Rigid solid and rigid stranded

5.23 rpm – Revolutions per minute

5.24 s – Seconds

5.25 SAE – Society of Automotive Engineers

5.26 sol – Solid

5.27 str – Stranded

5.28 V – Volts

6 Construction Requirements

6.1 General

6.1.1 The design and construction of a connector intended for use with stranded conductors shall be such that all strands of the conductor shall be contained within the connector. A connector that is suitable for compact-stranded conductors shall also accept all strands of a Class B concentric-stranded conductor of the same size.

6.1.2 A connector intended for use with conductors of different sizes shall have a clamping mechanism that adapts to conductors of different sizes without permanent removal or addition of parts. Some examples of clamping mechanisms are:

- a) direct bearing screws with or without use of a pressure plate;
- b) a pressure plate or plates and a screw or screws;
- c) deformation of the connector barrel (crimping) using a special tool;
- d) a nut threading onto a split bolt; and

- e) an element for insulation-piercing or displacement.

6.1.3 Any rearrangement or adjustment of a connector that is necessary to adapt it to various sizes of conductors shall be obvious unless the connector is marked as described in 10.11.

6.1.4 There shall be no sharp edges or corners on the outer surface of a connector that result in damage to insulation that the connector contacts.

6.1.5 The construction of a connector intended to secure more than a single conductor shall be such that there will be no intermixing (direct conductor contact) between the conductors of different materials unless the connector is investigated and found to meet the performance requirements of this Standard and is marked in accordance with 10.24.

6.2 Materials

6.2.1 The main current-carrying part of a connector shall be of aluminum, an aluminum alloy, copper, a copper alloy, or other material investigated and found to meet the performance requirements of this Standard.

6.2.2 A connector intended for use with aluminum conductor(s) or a connector body of aluminum or aluminum alloy shall be coated with an electrically conductive coating, such as tin, that will inhibit oxidation and corrosion. The following need not be coated:

- a) a splicing connector shipped prefilled with an oxide-inhibiting compound;
- b) the conductor-securing (barrel) portion of a terminal connector that is shipped prefilled with an oxide-inhibiting compound;
- c) an aluminum-bodied splicing connector that is intended for an aluminum conductor only;
- d) the cut ends of a neutral bar;
- e) the top cap of a lay-in connector not in contact with the wire; and
- f) the mounting hole in a connector that is intended to be secured by a bolt, nut, and washer.

Note: Other coatings may be used if investigated for the purpose and found suitable.

6.2.3 Iron or steel, if protected against corrosion, may be used for screws, plates, yokes, or other parts that are employed as a means of clamping the conductor, if such parts are not the primary current-carrying members.

6.2.4 Insulation employed as a part of the connector shall be suitable for its rated temperature in accordance with Table 1.

6.2.5 The insulating material shall have a minimum flammability classification of V-2 or VTM-2 as determined by tests described in Annex B. The material thickness for determining the flammability shall be measured at points supporting live parts or within 6 mm (0.236 in) of live parts, whichever is less.

Note: Insulating tubing that has a VW1 rating is not considered equivalent. Tubing may be tested using bar samples to achieve a V-2 minimum rating or the glow wire test (see 6.2.6) may be performed.

6.2.6 With reference to 6.2.5, a material other than V-2 or VTM-2 may be used when the insulation of the wire connector complies with the requirements for the glow-wire test as specified in UL 746C, or CSA C22.2 No. 0.17, or NMX-J-508-ANCE with a glow wire at a temperature of 750°C.

6.3 Soldering lugs

6.3.1 A soldering lug shall be made of copper, brass, bronze, or other material that has been shown by investigation to meet the requirements of this Standard.

6.3.2 A lug of other than wrought copper shall be subjected to an investigation that evaluates if the lug has performance equivalent to that of a wrought-copper lug.

6.3.3 The diameter and depth of the conductor hole, the wall thickness, and the contact area of the tang of a wrought-copper lug shall not be less than the values specified in Table 2, according to the maximum size of conductor that the lug is intended to accommodate.

6.3.4 The diameters and areas of screws or bolts have not been standardized, and no addition or subtraction for these has been made in determining the areas specified in Table 2.

7 Test Requirements

7.1 General

7.1.1 A connector shall meet the test requirements when separate sets of specimens are subjected to the applicable tests for the design of the connector as specified in Table 3 through Table 5 and in 7.10 through 7.13.

7.1.2 With reference to 7.1.1, a connector of copper or copper alloy need not be subjected to the current-cycling sequence using copper conductor.

7.1.3 With reference to 7.1.1, the initial static-heating test need not be conducted in the static-heating sequence using copper conductor.

7.1.4 With reference to 7.1.1, for other than a tool-applied crimp connector, the current-cycling test using a copper conductor need not be performed when the connector has been current-cycling tested with an aluminum conductor of a size not smaller than the size of the copper conductor required for the current-cycling test.

Note: See Annex C for example.

7.1.5 Conductor sizes 30 – 20 AWG (0.05 – 0.52 mm²) need not be subjected to the secureness test in the static-heating sequence or mechanical sequence.

7.1.6 Specimen sets shall be subjected to the test sequences using the conductor material specified in Table 6 for the one or more conductor material combinations for which the connector is intended. The dielectric withstand, stress corrosion, secureness of insulation, flexing, and low temperature installation tests shall be permitted to be conducted using either copper or aluminum conductor. When a connector is rated for copper-to-copper, aluminum-to-aluminum, and copper-to-aluminum (intermixed), the mechanical sequence with copper-to-aluminum conductors may be omitted.

7.1.7 A connector rated for Class 5 and 6 metric conductors (flexible stranded) shall be subjected to all test sequences using flexible metric conductors.

7.1.8 For a connector intended to be used with aluminum and copper conductor, specimens with aluminum conductor and copper conductor shall be subjected to the current-cycling, static-heating sequence, and mechanical sequence tests.

7.1.9 For an aluminum-bodied connector intended to be used with copper conductor only, specimens with copper conductor shall be subjected to the current-cycling, static-heating sequence, and mechanical sequence tests.

7.1.10 Tests conducted on a connector with compact-stranded conductors shall represent tests with concentric and compressed stranded conductors of the same size.

7.2 Current-cycling

7.2.1 The specimen sets shall complete 500 cycles of equal current-on and current-off operations for the periods of time specified in Table 7, other than as noted in 9.2.2 and 9.2.5, while carrying the current specified for the connector temperature rating and conductor size being tested.

7.2.2 The current-cycling test shall be completed without any connector exceeding a 125°C temperature rise above the ambient temperature for any recorded cycle.

7.2.3 The stability factor " S_i " (see 7.2.4) shall not exceed ± 10 for connector temperature measurements taken at approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles.

7.2.4 The stability factor " S_i " for each of the 11 temperature measurements shall be determined by applying the following equations:

$$S_i = d_i - D$$

$$D = [d_1 + d_2 + \dots + d_{11}]/11]$$

in which:

D is the average temperature deviation,

i is a number from 1 to 11 and signifies one of the 11 individual temperature measurements,
and

d_i is a temperature deviation for an individual temperature measurement.

Note: The value for d_i is determined by subtracting the control conductor temperature from the connector temperature. The value for d_i is a positive number when the connector temperature is more than that of the control conductor and a negative number when the connector temperature is less than that of the control conductor. The average of the 11 temperature deviations is then determined. See Annex D for example.

7.3 Static-heating sequence

7.3.1 The specimen sets shall carry continuously the value of 60 Hz test current specified in Table 7 or Table 8 for the conductor size being tested until stable temperatures are reached without exceeding a 50°C temperature rise above ambient temperature.

Note 1: The temperature rise on an ampere-rated connector may exceed 50°C when the connector, as used in the intended equipment application, does not exceed the maximum allowable temperature rise permitted for the end-use application.

Note 2: A current source may be maintained at or above the required value by regulation or frequent adjustment.

7.3.2 The joint between a connector and the conductor shall be intact after being subjected for 30 min to the secureness test described in 9.3.2.

7.3.3 The joint between a connector and the conductor of a specimen set shall be intact after being subjected for 1 min to the pullout test described in 9.3.4.

7.3.4 As a result of the tests, there shall be no breakage of the conductor or any strand of a stranded conductor, stripping of threads, shearing of parts, or other damage to the connector. Breaking of the conductor or any strand of a stranded conductor shall be determined by examination of the complete connector assembly while still intact after the secureness or pullout tests. Breakage has occurred if the conductor or a strand of a stranded conductor becomes visibly unattached. Strand breakage of 5 percent is allowed for flexible and fine stranded conductors.

7.4 Mechanical sequence

7.4.1 The joint between a connector and the conductor of a specimen set shall be intact after being subjected for 30 min to the secureness test described in 9.3.2.

7.4.2 The joint between a connector and the conductor of a specimen set shall be intact after being subjected for 1 min to the pullout test described in 9.3.4.

7.4.3 As a result of the tests, there shall be no breakage of the conductor or any strand of a stranded conductor, stripping of threads, shearing of parts, or other damage to the connector. Breaking of the conductor or any strand of a stranded conductor shall be determined by examination of the complete connector assembly while still intact after the secureness or pullout tests. Breakage has occurred if the conductor or a strand of a stranded conductor becomes visibly unattached. Strand breakage of 5 percent is allowed for flexible and fine stranded conductors.

7.5 Dielectric-withstand test sequence

7.5.1 An insulated wire connector shall withstand, without breakdown, the dielectric-withstand tests as specified in Table 9.

7.5.2 The insulation of an insulated connector shall not crack or break when the connector is assembled as intended on the conductor.

7.5.3 The oven conditioning described in 9.5.2.2, 9.5.2.3, and Table 10 shall not cause the connector insulation to harden, soften, crack, deform, loosen, or otherwise change so as to adversely affect the insulating properties of the conductor insulation or the connector insulation.

Note: Discoloration of the connector insulation is allowed.

7.6 Secureness of insulation

7.6.1 The insulation of a connector shall not be damaged and shall not become detached from the body of the connector when subjected to the secureness of insulation test described in 9.6.

7.7 Drop

7.7.1 A latch or a lock employed on the cover of an insulated splicing connector intended for use with a 4 AWG (21.1 mm²) or larger conductor shall not open or break when the connector is subjected to the drop test as specified in 9.7. Cracking or breakage of the remaining insulation shall be allowed when the assembly complies with the dielectric withstand after drop as specified in 7.8.

7.8 Dielectric withstand after drop

7.8.1 An insulated splicing connector that has been subjected to the drop test shall comply with the dielectric voltage-withstand as specified in 9.8.

7.9 Flexing

7.9.1 An insulating cover employing a hinge, a latch, or a lock shall retain its resilience and shall not crack when subjected to the flexing test specified in 9.9.

7.10 Low temperature installation

7.10.1 In Canada, insulated wire connectors with a thermoplastic or thermosetting material shall be capable of being assembled in accordance with 9.10 without cracking or fracture of the insulation. This test shall not apply to insulated wire connectors intended for factory installation only. See 10.39.

In the United States and Mexico, this requirement does not apply.

7.11 Moisture absorption

7.11.1 Porcelain or cold-molded composition used as insulation on connectors shall not absorb more than 3 percent of its mass when subjected to the moisture-absorption test as specified in 9.11.

7.12 Stress corrosion/moist ammonia (NH₄)

7.12.1 A copper alloy part of a connector shall be resistant to stress corrosion cracking.

Note: The moist ammonia test is considered an alternative to the mercurous nitrate test.

7.12.2 A copper alloy part containing more than 15 percent zinc shall be tested for stress corrosion cracking.

7.12.3 A copper alloy part containing more than 15 percent zinc shall show no evidence of cracking when examined using a 25X magnification after being subjected to the stress corrosion/moist ammonia (NH₄) test as specified in 9.12.

7.13 Stress corrosion/mercurous nitrate (HgNO₃)

7.13.1 A copper alloy part of a connector shall be resistant to stress corrosion cracking.

Note: The mercurous nitrate test is considered an alternative to the moist ammonia test.

7.13.2 A brass part containing less than 80 percent copper shall not crack when subjected to the stress corrosion/mercurous nitrate (HgNO₃) test in 9.13.

8 Sampling Requirements

8.1 General

8.1.1 See Table 11 for the minimum number of specimens for test.

8.1.2 Separate specimen sets shall be used for current-cycling, mechanical sequence, static-heating sequence, dielectric-withstand tests and the other tests as applicable. See Table 3, Table 4, Table 5, and Table 9.

8.1.3 The basic specimen set for the current-cycling tests, mechanical sequence, and static-heating sequence shall consist of four connectors for each combination of connector and test conductor or conductors to be tested.

8.1.4 With reference to 8.1.3, for testing a splicing connector or run and tap connector in which each conductor is secured by a separate means, the specimen sets shall consist of two connectors for each combination of connector and test conductor to be tested.

8.1.5 With reference to 8.1.3, for a neutral bar, the basic specimen set shall consist of two specimens of three connector holes cut from a length of the neutral bar. The distance between the holes cut from the neutral bar shall be representative of the minimum distance.

8.1.6 With reference to 8.1.3, for a connector intended for a conductor size range of 30 – 10 AWG (0.05 – 5.3 mm²) copper and 12 and 10 AWG (3.3 and 5.3 mm²) aluminum, the basic sample set for the static-heating sequence shall consist of two connectors for each combination of connector and test conductor to be tested.

8.1.7 For a line of connectors of similar design but of different sizes, the following sizes shall be tested:

- a) the largest and the smallest sizes if the line consists of four sizes or less;
- b) the largest, smallest, and one representative intermediate size if the line consist of five sizes; and
- c) the largest, smallest, and two representative intermediate sizes if the line consists of more than five sizes.

8.1.8 A line of connectors of similar design is determined by the following features:

- a) shape of connector, shape of conductor opening, and shape and number of clamping screws;
- b) material and surface treatment of the connector body, tang, clamping screw, and pressure bar;
- c) torque corresponding to the wire size of each connector;
- d) crimping die design and number of crimps for connectors using crimping tools; and
- e) for a tangless connector, the material and plating of the associated tang to be used with the connector.

8.1.9 Specimens shall be tested using both solid and stranded conductor for 30 – 10 AWG (0.05 – 5.3 mm²) conductor sizes, and using stranded conductor for 8 AWG (8.4 mm²) and larger unless the conductor is marked in accordance with 10.13, in which case the conductor used shall be of the type or types marked on the connector.

8.1.10 If the conductor range of a connector includes sizes 14 – 10 AWG (2.1 – 5.3 mm²), and these sizes are not included in the test sample selection, additional sample sets shall be tested using the maximum size solid conductor in the range of 14 – 10 AWG (2.1 – 5.3 mm²).

8.1.11 Testing using AWG/kcmil conductors is representative of Class 1 and 2 metric conductors (rigid solid and rigid stranded) within the cross-sectional area envelope of the rated AWG/kcmil range. Class 5 and 6 metric conductors (flexible stranded) shall additionally comply with the requirements in 7.1.7.

8.1.12 A connector that is designed to employ clamping screws made for either aluminum, brass, or steel shall be tested with clamping screws made of the material specified in Table 12.

8.2 Current-cycling

8.2.1 For a connector without an assigned ampere rating, specimens shall be tested using the maximum size conductor or conductors. For a connector intended for a single conductor and also for paralleling conductors, current-cycling tests shall be conducted on specimens using the maximum single and maximum parallel conductor sizes. For a connector that is intended for a range of conductor sizes and for copper conductor in addition to aluminum conductor, current-cycling tests with copper conductor need not be performed if the size that is selected results in a test current that is less than or equal to the test current used in the tests with aluminum conductor. Also see 7.1.4.

Note: The current used in the tests with aluminum conductor may be raised above the required value with the concurrence of those concerned.

8.2.2 For a connector with an assigned ampere rating, specimens shall be tested using the size or sizes of the conductor corresponding to the assigned maximum ampere rating and connector temperature rating as indicated in Table 7. If the assigned maximum ampere rating of a connector falls between the two values of assigned ampere rating specified in these tables, the test current used shall be that which corresponds to the higher assigned rating. For connectors intended for paralleling conductors, the conductor sizes shall be selected in accordance with Table 7, and the current shall be selected in accordance with Table 13. For a connector that is intended for a range of conductor sizes and for copper conductors in addition to aluminum conductors, current-cycling tests with copper conductors are not required to be conducted if the size that is selected results in a test current that is less than or equal to the test current used in the tests with aluminum conductors.

Note: The current used in the tests with aluminum conductors may be raised above the required value with the concurrence of those concerned.

8.2.3 For a connector with an assigned ampere rating and intended for a single conductor and also for paralleling conductors, the current-cycling test shall be conducted on specimens using the conductor combination or conductor size as selected for the static-heating test. For a connector that is intended for a range of conductor sizes and for copper conductors in addition to aluminum conductors, heat-cycling tests with copper conductors need not be conducted if the size that is selected results in a test current that is less than or equal to the test current used in the tests with aluminum conductors.

Note: The current used in the tests with aluminum conductors may be raised above the required value with the concurrence of those concerned.

8.2.4 With reference to 7.1.6 and Table 6, if the connector is intended for the intermixing of conductors of different materials, the heat-cycling tests shall be conducted using the following conductor material:

- a) maximum size copper with maximum size aluminum;
- b) maximum size copper with minimum size aluminum;
- c) minimum size copper with minimum size aluminum; and

d) maximum size copper in combination with a minimum size aluminum conductor or conductors where the sum of test currents of the minimum size conductors is approximately equal to the current of the maximum size conductor.

The test currents are based on the lesser current dictated by the two different conductor materials.

8.3 Static-heating sequence

8.3.1 A connector without an assigned ampere rating and intended for use with a range of conductor sizes shall be tested with the maximum size conductor. If more than one conductor is secured by a single clamping means, additional specimens shall be subjected to this test or the mechanical sequence test, as necessary.

8.3.2 For an ampere-rated connector not intended for paralleling conductors, the static-heating sequence shall not be conducted with the larger size(s) of conductor that exceed the size conductor that corresponds to the ampere rating of the conductor as determined from Table 7; only the mechanical sequence tests shall be conducted. A connector specimen set with the size conductor that corresponds to the ampere rating shall be subjected to the full static-heating sequence.

Note: See Annex C for example.

8.3.3 For an ampere-rated connector intended for paralleling conductors, specimens shall be tested with the parallel conductor combinations that equal the assigned ampere rating as determined from Table 7. The ampere rating assigned to the connector shall be divided by the number of conductors. For ampere ratings that fall between two consecutive values, the next larger conductor size shall be used. The values of test current in the static-heating test for the parallel-conductor range shall be selected from Table 8. If the number of conductors is less than the number of conductor openings, the conductors shall be positioned in the connector so that the test current is concentrated in the smallest cross-sectional area of the connector in the current path. If the connector also has single conductor ranges, the conductor sizes and values of test current in the static-heating tests for the single conductor ranges shall be selected from Table 7 using the conductor size that corresponds to the ampere rating of the connector.

Note: See Annex C for example.

8.3.4 For the static-heating sequence where intermixing of conductor types is involved, the same selection of samples as indicated in 8.2.4 shall be tested.