UL 486C

STANDARD FOR SAFETY

Splicing Wire Connectors

UL Standard for Safety for Splicing Wire Connectors, UL 486C

Sixth Edition, Dated January 11, 2013

Summary of Topics

This new edition of ANSI/UL 486C includes the following changes: a) Editorial revisions; b) Addition of Single Input Wire (SIW) requirements; c) Reusable and nonreuseable wire sizes; d) Insulation puncture and flashover test voltage; e) Correction to Table 1; f) Correction to Table 8; g) Table 10 and clause 9.1.5.4 conflict; and h) Bushing diameter tolerance.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 24, 2012.

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 preface. 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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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Association of Standardization and Certification
NMX-J-548-ANCE
Third Edition

Canadian Standards Association
CSA C22.2 No. 188-13
Third Edition

Underwriters Laboratories Inc.
UL 486C
Sixth Edition

Splicing Wire Connectors

January 11, 2013

ANSI/UL 486C-2013

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as "CSA Group"), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group 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 Group and UL pages.

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This Standard is subject to periodic review, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquires@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Sixth Edition. The most recent designation of ANSI/UL 486C as an American National Standard (ANSI) occurred on January 11, 2013. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

The Department of Defense (DoD) has adopted UL 486C on January 28, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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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Preface

This is the harmonized ANCE, CSA Group, and UL standard for Splicing Wire Connectors. It is the third edition of NMX-J-548-ANCE, the third edition of CSA C22.2 No. 188, and the sixth edition of UL 486C. This edition of NMX-J-548 cancels the previous edition published in 2008. This edition of CSA C22.2 No. 188 supersedes the previous edition published in 2004. This edition of UL 486C supersedes the previous edition published in 2004.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), the CSA Group, 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 is considered suitable for use for conformity assessment within the stated scope of the Standard.

This standard was reviewed by the CSA Integrated Committee on Electrical Connectors, 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 has been approved by the American National Standards Institute (ANSI) as an American National Standard.

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 to be considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, 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 would 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 Group effective date

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

UL effective date

As of January 11, 2013 all products Listed or Recognized by UL must comply with the requirements in this standard.

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

1 Scope

1.1 This Standard applies to single-polarity, hand- or tool-applied splicing wire and cable connectors intended for use with all alloys of copper, aluminum conductors, or copper-clad aluminum conductors, or all three, 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:

Note: Copper-clad aluminum conductors are for use only in the United States in accordance with the National Electrical Code, NFPA 70.

a) connectors intended to hold two or more conductor(s);

b) connectors intended for use in appliances and equipment that comply with the requirements for such appliances and equipment;

c) connectors intended for use with 6 AWG (13.3 mm^2) or smaller conductors; and

d) uninsulated connectors that are used in circuits rated 8 000 V and less.

Note: Examples of splicing wire connectors include twist-on connectors, insulation-piercing or displacement connectors, spring-action connectors, tool-applied crimp, mechanical set-screw connectors, etc.

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

a) Aluminum:

1) 12 AWG (3.3 mm^2) and 10 AWG (5.3 mm^2) solid;

2) 12 AWG (3.3 mm^2) to 6 AWG (13.3 mm^2) stranded, Class B concentric, compressed, and compact; and

3) 12 AWG (3.3 mm^2) to 6 AWG (13.3 mm^2) stranded single input wire (SIW).

In Mexico, the use of aluminum conductors is permitted only with thermoset insulation and for sizes of 6 AWG (13.3 mm^2) and higher.

b) Copper-clad aluminum:

1) In Canada, this construction is not allowed.

2) In Mexico, this construction is not allowed.

3) In the United States:

i) 12 AWG (3.3 mm^2) and 10 AWG (5.3 mm^2) solid; and

ii) 12 AWG (3.3 mm^2) to 6 AWG (13.3 mm^2) stranded, Class B concentric, compressed, and Class C concentric.

c) Copper:

1) 30 AWG (0.05 mm^2) to 10 AWG (5.3 mm^2) solid; and

2) 30 AWG (0.05 mm^2) to 6 AWG (13.3 mm^2) stranded, Class B concentric and compressed, and Class C concentric.

d) Compact-stranded copper conductors:

In Canada and Mexico, for 8 AWG (8.4 mm^2) and 6 AWG (13.3 mm^2).

In the United States this is not applicable.

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

Note: For example, a connector rated for 6 AWG (13.3 mm^2) – 14 AWG (2.1 mm^2) may be additionally rated for 10 – 2.5 mm^2.

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

1.3 These requirements cover splicing wire connectors intended for:

a) copper-to-copper;

b) aluminum-to-aluminum;

c) copper-clad aluminum-to-copper-clad aluminum;

d) copper-to-aluminum or copper-clad aluminum and aluminum-to-copper-clad aluminum conductor combinations intended for intermixing of conductors and dry locations only; or

e) all of the above.

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

1.5 This Standard does not apply to:

a) insulated splicing wire connectors intended for use at voltage levels in excess of 600 V [1 000 V in a sign or luminaire];

b) terminal wire connectors;

c) wire binding screw terminals;

d) built-in terminal connectors on devices rated less than 30 A and intended for outlet box mounting or having provision for stress relief;

e) built-in terminal connectors on devices having integral cable clamps;

f) flat quick connect terminals; and

g) soldering lugs.

2 Reference publications

2.1 Normative references

Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

2.1.1 ANCE Standards

NMX-J-192-ANCE
Electrical Products – Wires and Cables – Flame Test on Electrical Wires – Test Method

NMX-J-218-ANCE
Wires and Cables – Aluminum 1350 Drawing Stock for Electrical Purposes – Specifications

NMX-J-417-ANCE
Wires and Cables – Convection Laboratory Ovens for Evaluation of Electrical Insulation – Specifications and Test Methods

NMX-J-508-ANCE
Electrical Fittings – Safety Requirements – Specifications and Test Methods

2.1.2 CSA Standards

C22.1-12
Canadian Electrical Code, Part 1 (CEC)

CAN/CSA-C22.2 No. 0.17-00 (R2009)
Evaluation of Properties of Polymeric Materials

2.1.3 UL Standards

UL 746C
Polymeric Materials – Use in Electrical Equipment Evaluations

2.1.4 NFPA* Standards

ANSI/NFPA 70-2011
National Electrical Code (NEC)

* National Fire Protection Association

2.1.5 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 measure

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

4 Definitions

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

4.1 Circular Mil (Cmil) – the area of a circle with a diameter of 0.001 in.

4.2 Control Conductor – an unbroken conductor that is included in the current-cycling test loop.

4.3 Crimping Die – that part of a crimping tool which forms the crimp(s) and usually incorporates the crimp anvil(s), the crimp indentor(s), and the positioner.

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

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

4.5 Packaging Container – the container in which the unit containers are packaged.

4.6 Single Input Wire (SIW) – a stranded conductor that varies the number of wires within a range of conductor sizes in order to permit that range of conductor sizes to be constructed from a single wire size.

4.7 Splicing Wire Connector – a connector that establishes a connection between two or more conductors by means of mechanical pressure and is not intended to be permanently mounted.

4.8 Stability Factor S – the measure of temperature stability of a connector during the current-cycling test.

4.9 Temperature Rating – the maximum temperature of an insulated connector assigned by the manufacturer.

4.10 Temperature Rise – the difference of the temperature of the connector, measured under load, and the ambient temperature.

4.11 Unit Container – the smallest container in which connectors are packaged.

4.12 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 CC or CCA – Copper-clad aluminum

5.7 Cu – Copper

5.8 d – Days

5.9 f – Flexible

5.10 h – Hour

5.11 $HgNO_3$ – Mercurous nitrate

5.12 Hz – Hertz, cycles per second

5.13 in – Inches

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 mm^2 – Square millimeter

5.20 N – Newton – Kilogram meter/sec^2

5.21 NH_4 – 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.

6.1.2 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.

6.1.3 The clamping or twist-on movement of a connector shall adapt it for use with conductors of different sizes, when such use is intended, without permanent removal or addition of parts. Examples of clamping means are:

a) direct-bearing screws with or without use of a pressure plate;

b) deformation of the connector barrel (crimping) using a special tool;

c) element for insulation piercing or insulation displacement;

d) spring-action clamp;

e) helical coiled spring; and

f) formed insulation cavity (no spring).

6.1.4 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.

6.1.5 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.

6.2 Intermixing

6.2.1 Intermixing (direct conductor contact) between conductors of different materials shall be permitted if the connector meets the performance requirements of this standard and is marked in accordance with 10.5d).

6.3 Materials

6.3.1 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.

6.3.2 Except as specified in 6.3.3, a connector body of a copper, copper alloy, aluminum, or aluminum alloy and intended for aluminum conductor shall be coated with an electrically conductive coating, such as tin, that will inhibit oxidation and corrosion.

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

6.3.3 With reference to 6.3.2, the following need not be coated:

a) a connector shipped prefilled with an oxide-inhibiting compound; and

b) a connector of aluminum or aluminum alloy that is intended for aluminum conductor only.

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

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

6.3.6 Insulation employed as a part of the connector shall be suitable for the tested voltage rating of the connector in accordance with Table 2.

6.3.7 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 3 mm (0.118 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 6.3.8) may be performed.

6.3.8 With reference to 6.3.7, 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 CAN/CSA-C22.2 No. 0.17, or NMX-J-508-ANCE, with a glow wire at a temperature of 750 °C.

6.3.9 The insulation color of a twist-on or set-screw connector rated for aluminum conductor shall be purple or brown. The insulation color of a twist-on or set-screw connector rated for copper wire only shall be any color other than purple or brown.

7 Test requirements

7.1 General

7.1.1 A connector shall meet the test requirements when separate specimen sets are subjected to the tests in Table 3 and Table 4, as applicable, for the design of the connector.

7.1.2 For a tool-applied crimp-on connector, when the conductors are secured by a single securing means, tests shall be conducted with the conductors pre-twisted according to the instructions provided by the manufacturer and according to 10.12d) and 10.18. The conductors shall not be required to be pre-twisted when the design of the connector does not lend itself to direct contact, such as a butt-end splice.

7.1.3 With reference to 7.1.2, at the manufacturer's option, tests of connectors intended for original equipment manufacturer (OEM) use may be conducted with the conductors not pre-twisted. However, instructions for pre-twisting the conductors shall be provided for field-wiring applications. Instructions for pre-twisting shall be optional for OEM wiring applications. If the connector can be crimped without providing direct contact between the conductors, then tests shall be conducted with the connector crimped so they are not in direct contact. Connectors tested with the conductors not pre-twisted shall be marked as specified in 10.19.

7.1.4 For the current-cycling, static-heating sequence, and mechanical sequence tests, when more than a single conductor is secured by a single securing means, tests on duplicate specimens shall be conducted to represent the most severe conductor position conditions that could result when conductors are assembled into the connector.

7.1.5 A connector of copper or copper alloy need not be subjected to the current-cycling test using copper conductors, unless the connector is dependent upon insulation piercing, insulation displacement, or spring action.

7.1.6 A twist-on connector provided with a metal insert need not be subjected to the current-cycling test using copper conductors. A twist-on connector not provided with a metal spring shall be subjected to the current-cycling test.

7.1.7 With reference to 7.1.5 and 7.1.6, a pre-filled twist-on connector, with or without a spring insert, shall also be subjected to the current-cycling test using copper conductors.

Note: Pre-filling usually consists of a gel, epoxy, anti-oxidant, or similar compound.

7.1.8 The initial static-heating test need not be conducted in the static-heating sequence using copper conductor.

7.1.9 Conductor-sizes 30 – 20 AWG (0.05 – 0.52 mm^2) need not be subjected to the secureness test in the static-heating sequence or mechanical sequence.

7.1.10 Specimen sets shall be subjected to the test sequences using the conductor material specified in Table 5 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 may be conducted using either copper or aluminum or copper-clad aluminum conductor. When a connector is rated for copper-to-copper, aluminum-to-aluminum, and copper-to-aluminum (intermixed), or copper-clad aluminum, the mechanical sequence with copper-to-aluminum conductors may be omitted.

7.1.11 Testing using AWG conductors shall be considered representative of Class 1 and 2 metric conductors (rigid solid and rigid stranded) within the cross-sectional area envelope of the rated AWG range. A connector rated for Class 5 and 6 metric conductors (flexible stranded) shall be subjected to all test sequences using flexible metric conductors.

7.1.12 Tests conducted on a connector with compact-stranded conductors shall be considered representative of concentric and compressed stranded conductors of the same size.

7.2 Current cycling

7.2.1 The specimen sets shall complete 500 continuous cycles of current-on and current-off operations, while carrying the current corresponding to the conductor size as specified in Table 6. Other than as noted in 9.2.3, each cycle of operation shall consist of 1 h on and 1 h off.

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

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:

$$S_i = d_i - D$$

$$D = [(d_1 + d_2 + ... + d_{11}) / 11]$$

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 C 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 6 for the conductor size being tested until stable temperatures are reached without exceeding a 50 °C temperature rise above ambient temperature.

Note: 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 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 all classes of conductors other than B and C.

7.4 Mechanical sequence

7.4.1 The joint between a connector and the conductor shall be intact after being subjected for 30 min to the test described in 9.4.1.

7.4.2 The joint between a connector and the conductor shall be intact after being subjected for 1 min to the test described in 9.4.2.

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 specified in Table 7.

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 and 9.5.2.3 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 in 9.6.

7.7 Flexing

7.7.1 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 9.7.

7.8 Low temperature installation

7.8.1 In Canada, the thermoplastic or thermosetting insulation of a compression-type connector assembled by a tool shall not crack or fracture when installed and tested in accordance with 9.8. This test shall not apply to insulated wire connectors intended for factory installation only.

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

7.9 Moisture absorption

7.9.1 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 specified in 9.9.

7.10 Stress corrosion/moist ammonia (NH_4)

7.10.1 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.

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

7.10.3 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 (NH_4) test specified in 9.10.

7.11 Stress corrosion/mercurous nitrate ($HgNO_3$)

7.11.1 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.

7.11.2 A brass part containing less than 80 percent copper shall not crack when subjected to the stress corrosion/mercurous nitrate ($HgNO_3$) test specified in 9.11.

7.12 Spring action

7.12.1 After being subjected to the conditioning in 9.12.1, a spring-action connector shall not exceed a temperature rise of 50 °C above the ambient temperature when tested as specified in 9.12.2.

7.12.2 A spring-action connector shall withstand without dielectric breakdown the application of the test potential when tested as specified in 9.12.3.

7.13 Over-torque

7.13.1 A connector to which torque is applied by means of a blade-type screwdriver shall withstand the values of torque as specified in 9.13. There shall be no shearing of parts, stripping of threads, or other damage to the connector.

7.14 Separable part securement

7.14.1 Connector insulation consisting of separable parts, such as a body and cap, shall not separate or become detached after being subjected to the test described in 9.14.

8 Sampling requirements

8.1 General

8.1.1 See Table 8 for the minimum number of specimens for test.

8.1.2 Separate specimen sets shall be used for each of the test sequences in Table 3 and Table 4.

8.1.3 Specimen sets shall be tested using both solid and stranded conductors for 30 – 10 AWG (0.05 – 5.3 mm^2) sizes, and using stranded conductor for 8 AWG (8.4 mm^2) and larger sizes unless the connector is marked as specified in 10.8, in which case the conductor used shall be of the type or types marked on the connector.

8.1.4 With reference to 8.1.3, for twist-on wire connectors, the dielectric-withstand test shall be performed on solid conductors only unless the connector is designed for stranded wire only.

8.1.5 If the conductor range of a connector includes sizes 14 – 10 AWG (2.1 – 5.3 mm^2), 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 mm^2).

8.1.6 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 consists of five sizes; and

c) the largest, smallest, and two representative intermediate sizes if the line consists of more than five sizes.

8.1.7 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; and

d) crimping die design and number of crimps for connectors using crimping tools.

8.1.8 With reference to 8.1.6, all models of twist-on wire connectors shall be tested.

8.2 Current cycling

8.2.1 The basic specimen set shall be in accordance with Table 8 for each combination of connector and test conductor(s) to be tested.

8.2.2 For a connector that is intended for splicing two conductors of the same AWG (mm^2) size, specimen sets shall be tested using the maximum size conductor; see 8.1.3 and 8.1.5.

Note: See Annex D for example.

8.2.3 When a connector is also intended for use with more than two conductors or two or more combinations of conductors differing in the number or sizes, or both, current-cycling tests shall be conducted with the maximum size conductor in combination with the minimum size conductors where the sum of the test currents of the minimum size conductors is approximately equal to but not greater than the current of the maximum size conductor. The combination selected shall have the largest gap between the maximum and minimum conductor sizes.

Note: See Annex D for example.

8.2.4 For a connector that is intended for copper conductors in addition to aluminum conductors or copper-clad aluminum conductors, current-cycling tests with copper conductors need not be conducted when the copper conductor 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 or copper-clad aluminum conductors.

Note: The current used in the tests with aluminum conductors or copper-clad aluminum conductors may be raised to the value normally used with copper conductors, with the concurrence of those concerned.

8.2.5 With reference to 7.1.10 and Table 5, when the connector is intended for the intermixing of conductors of different materials, the current-cycling tests shall be conducted using the following conductor material:

a) maximum size copper with maximum size aluminum or copper-clad aluminum;

b) maximum size copper with minimum size aluminum or copper-clad aluminum;

c) minimum size copper with minimum size aluminum or copper-clad aluminum; and

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

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

8.2.6 In addition to the tests specified in 8.2.5, when the connector is intended for the intermixing or direct contact of two or more aluminum conductors in combination with one or more copper conductors in the same wire opening, additional current cycling and static-heating sequences shall be conducted with the test current flowing from aluminum to aluminum. The copper conductor shall not conduct current, but shall only be used to assemble the specified wire combination. The test currents shall be based on the aluminum test current values specified in Table 6. The following combinations shall be tested:

a) maximum size aluminum (2 conductors) with maximum size copper (1 conductor);

b) maximum size aluminum (2 conductors) with minimum size copper (1 conductor);

c) minimum size aluminum (2 conductors) with maximum size copper (1 conductor); and

d) minimum size aluminum (2 conductors) with minimum size copper (1 conductor).

8.3 Static-heating sequence

8.3.1 The basic specimen set shall be in accordance with Table 8 for each combination of connector and test conductor(s) to be tested.

8.3.2 For the static-heating sequence, the same selection of specimen sets as indicated in 8.2 shall be tested.

8.4 Mechanical sequence

8.4.1 For a connector intended to secure more than one conductor at a time by a single clamping means and intended for use with two or more combinations differing in number of conductors, conductor sizes, or both, the following combinations of conductors shall be subjected to the tests specified in 9.4:

a) smallest total circular-mil area;

b) largest total circular-mil area;

c) smallest number of smallest stranded conductors with smallest number of largest stranded conductors;

d) smallest number of smallest solid conductors with smallest number of largest solid conductors;

e) largest number of smallest solid conductors;

f) largest number of smallest stranded conductors;

g) smallest number of largest conductors;

h) two conductors of the same minimum AWG (mm^2) size; and

i) a single maximum AWG (mm^2) size conductor with a single minimum AWG (mm^2) size conductor.

The basic specimen set shall be in accordance with Table 8 for each combination of connector and test conductor(s) to be tested.

8.4.2 When any combination of conductors selected according to 8.4.1 is the same as another combination in 8.4.1, the test need only be conducted on a single specimen set. The mechanical sequence on any particular combination need not be repeated if it has been conducted as part of the static-heating sequence.

8.4.3 For a connector intended for use with a range of conductor sizes and intended to secure a single conductor in an opening, the mechanical sequence test shall be conducted with the maximum and minimum size conductor. The mechanical sequence on any particular conductor size need not be repeated if it has been conducted as part of the static-heating sequence.

8.5 Dielectric withstand

8.5.1 The tests to be conducted and the number of specimens for each test shall be as specified in Table 8. Different specimens shall be used for each test condition.

8.5.2 For a connector intended to secure combinations of conductors of different total cross-sectional areas, tests shall be performed on the combination of conductors of the smallest total cross-sectional area and on the combination of largest total cross-sectional area.

8.5.3 For a connector intended to secure single conductors of different sizes, tests shall be performed on specimens with the smallest and largest conductors.

8.5.4 When the connector has multiple voltage ratings, testing shall be conducted using the combinations in 8.5.2 and 8.5.3 at the different voltage ratings.

8.6 Secureness of insulation

8.6.1 The number of specimens as identified in Table 8 shall be subjected to the secureness of insulation test specified in 9.6.

8.7 Flexing

8.7.1 The number of specimens identified in Table 8 shall be subjected to the flexing test specified in 9.7.

8.8 Low temperature installation

8.8.1 In Canada, the number of specimens identified in Table 8 shall be subjected to the low temperature installation test specified in 9.8. Six specimens shall be assembled with the combination of conductors of the smallest total cross-sectional area and six specimens shall be assembled with the combination of conductors of the largest total cross-sectional area.

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

8.9 Moisture absorption

8.9.1 The number of specimens identified in Table 8 shall be subjected to the moisture-absorption test specified in 9.9.

8.10 Stress corrosion/moist ammonia (NH_4)

8.10.1 The number of specimens identified in Table 8 shall be subjected to the stress corrosion/moist ammonia (NH_4) test specified in 9.10.

8.11 Stress corrosion/mercurous nitrate ($HgNO_3$)

8.11.1 The number of specimens identified in Table 8 shall be subjected to the stress corrosion/mercurous nitrate ($HgNO_3$) test specified in 9.11.

8.11.2 The test shall be conducted on a specimen previously unused and not attached to a conductor or otherwise subjected to external stress.

8.12 Spring-action sequence

8.12.1 The number of specimens identified in Table 8 shall be subjected to the spring-action sequence test specified in 9.12.

8.12.2 The connector and the following combinations of conductors shall be subjected to the conditioning, temperature, and dielectric-withstand tests specified in 9.12:

a) the maximum size conductor;

b) the minimum size conductor when a range of conductor sizes is to be accommodated; and

c) the minimum size conductor in conjunction with the maximum size conductor in adjacent openings.

8.13 Over-torque

8.13.1 The number of specimens identified in Table 8 shall be subjected to the over-torque test specified in 9.13.

8.14 Separable part securement

8.14.1 The number of specimens identified in Table 8 shall be subjected to the separable part securement test specified in 9.14.

9 Test methods

9.1 General

9.1.1 Temperature measurement

9.1.1.1 Temperatures shall be measured by thermocouples consisting of conductors not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.005 mm^2).

9.1.2 Ambient temperature measurement

9.1.2.1 Test assemblies shall be located in a substantially vibration-free and draft-free location where the average ambient air temperature can be maintained in the range of 15 – 35 °C. The ambient temperature shall be kept within ± 4 °C at all times during the test.

9.1.2.2 Thermocouples to measure the ambient temperature for a connector specimen under test shall be installed on 50.8 mm (2 in) square by 6.4 mm (1/4 in) thick sections of unplated copper bus. All buses shall be mounted in a vertical plane at the same elevation as the wire connectors being tested. All measurements shall be made to the centerline of the nearest connector or control conductor. If all thermocouples employed are the same length, they shall be connected in parallel to provide an average ambient temperature.

9.1.2.3 For vertically mounted connectors, one bus shall be located 610 mm (2 ft) in front and one bus 610 mm (2 ft) in back of the specimens and control conductor. For test assemblies employing an insulating backboard as mentioned in 9.1.10.9, no bus section shall be mounted behind the test assembly.

9.1.2.4 For horizontally mounted connectors in an assembly of one or more specimens of connectors, bus sections shall be located 610 mm (2 ft) in front, 610 mm (2 ft) in back, and 610 mm (2 ft) on each side of the test assembly. As an alternate method of locating the thermocouple for a horizontal test assembly, one bus may be placed at the center of a loop formed by the specimens and control conductor.

9.1.3 Control-conductor temperature measurement

9.1.3.1 A thermocouple shall be located on each control conductor.

9.1.3.2 A thermocouple on a control conductor used in the current-cycling test shall be located at the midpoint of the conductor and under the conductor insulation. The thermocouple shall be secured by soldering, by use of an adhesive, or by other equivalent means. The conductor insulation shall be replaced over the thermocouple location. The surface of the conductor metal shall not be penetrated. Drilling and peening shall not be used.

9.1.3.3 For temperature measurements on a copper control conductor, the following technique shall be employed:

a) A small flap shall be cut into the conductor insulation and rolled back to expose the conductor.

b) The thermocouple bead shall be positioned in the valley between conductor strands or on the surface of a solid conductor.

c) The flap of insulation shall be repositioned and secured by a tightly wrapped, double layer of black thermoplastic tape extending not more than 12.7 mm (1/2 in) on each side of the flap, or by another similar means of holding the test conductor insulation in place.

9.1.3.4 For temperature measurements on an aluminum control conductor, if a thermally conductive adhesive which maintains direct contact with the strand of the control conductor is used, the technique specified in 9.1.3.3 shall be used. When a thermally conductive adhesive is not used, the following technique shall be used:

a) A 25.4 mm (1 in) minimum length of insulation over the full circumference of the conductor shall be removed.

b) For a solid conductor, the thermocouple shall be secured to the surface of the conductor.

c) One conductor strand shall be pried out of the stranding just enough to insert the end of a soft copper ribbon measuring 6.4 mm (1/4 in) wide by 0.13 mm (0.005 in) thick to a length that overlaps approximately 3.2 mm (1/8 in), as illustrated in Figure 1. The conductor strand shall then be lightly tapped back down on the copper ribbon.

d) The copper ribbon shall be wrapped partially around the conductor strands back to the one strand that has been pried out.

e) The thermocouple shall be located on the copper ribbon in the valley formed by the pried-out strand and the adjacent strand and shall be soldered in place. The copper ribbon shall be wrapped completely around the bundle of strands and shall be cut off so that a 3.2 mm (1/8 in) overlap results. The ribbon shall be secured in place by reheating the solder behind the ribbon where the thermocouple is located.

f) The section of insulation removed as described in a) shall be attached with the slit side directly opposite the thermocouple junction. Thin-walled heat shrinkable 125 °C tubing or a tightly wrapped, double layer of black thermoplastic tape extending not more than 12.7 mm (1/2 in) on each end of the section of insulation shall be used to hold it in place.

9.1.4 Specimen temperature measurement

9.1.4.1 A thermocouple on a wire connector shall be positioned to sense the highest temperatures generated by the connector. A thermocouple shall be installed so as to obtain thermal and mechanical bonding with the surface of a connector and without causing an appreciable change in the temperature of the connector.

9.1.4.2 When the size of the connector is such that the thermocouple cannot be attached to the body of the connector:

a) The thermocouple shall be attached to the maximum size conductor – as described in 9.1.3.3 or 9.1.3.4 – not more than 12.7 mm (1/2 in) from the edge of the connector; or

b) The thermocouple shall be installed inside the assembled connector where direct contact is made with the bundled conductors.

9.1.4.3 A test specimen shall be considered stable during the static-heating test when three temperature readings taken at not less than 10 min intervals show no more than a 2 °C variation between the three consecutive readings.

9.1.5 Test and control conductors

9.1.5.1 All test specimen conductors and control conductors shall comply with the requirements in Table 9, Table 10, and Table 11. All test specimen conductors and control conductors shall be new (previously unused) or, with the concurrence of those concerned, may be previously used conductors that have not attained a temperature of over 120 °C in previous testing. For previously used conductors, used conductor ends shall be cut off and the resulting new ends of the conductor re-stripped in accordance with 9.1.6.

9.1.5.2 In Canada and Mexico, test conductors for connectors rated for stranded copper conductors 8 – 6 AWG (8.4 – 13.3 mm^2) shall be Class B and compact rather than concentric or compressed, as specified in Table 9.

In the United States, this requirement does not apply.

9.1.5.3 A connector for flexible copper conductor other than Class B or Class C stranding shall be subjected to all test sequences using the other stranding.

9.1.5.4 The insulation for conductors shall be black or, with the concurrence of those concerned, insulation color other than black shall be allowed.

9.1.5.5 The conductor shall be examined to verify that the insulation has not penetrated beyond the first strand layer during the manufacturing process.

Note: A separator may be located between the conductor and the insulation of a stranded conductor to attain the required separation.

9.1.5.6 The length measured from the conductor entry face of the test connector to the equalizer for the current-cycling test or to the face of the connector at the other end of the test conductor for the mechanical or static-heating test shall be as specified in Table 12.

9.1.5.7 The length of control conductors used in the current-cycling tests shall be a minimum of twice the length of the test conductors used with the connector specimens.

9.1.6 Conductor stripping

9.1.6.1 Conductors shall be stripped immediately prior to installation for a distance that is proper for insertion into the connector and shall be assembled in the connector in the intended manner. The conductor shall not be brushed or abraded prior to installation into the connector. The insulation shall be stripped off the conductor so as to provide a clean abrupt end (not pencilled).

Note 1: Care should be taken in stripping conductors to avoid cutting, nicking, scraping, or other damage to the conductors. Care should be taken in removing all foreign materials such as insulation, separators, and the like from the stripped ends.

Note 2: For an insulation-piercing connector, the removal of the outer sheath of a cable, if necessary, is not considered to be stripping.

9.1.6.2 For an insulated or non-insulated connector marked with a nominal strip length according to 10.12 c), all tests, except for the dielectric-withstand test, shall be performed with conductors stripped to the nominal value minus the tolerance specified in Table 13. The dielectric-withstand test on an insulated connector shall be performed with conductors stripped to the marked nominal strip length.

9.1.6.3 For an insulated connector marked with a maximum conductor strip length and a minimum conductor strip length according to Table 14, all tests, except the dielectric-withstand test, shall be performed with conductors stripped to the minimum length. The dielectric-withstand test shall be performed with conductors stripped to the maximum length. For a non-insulated connector marked with a minimum conductor strip length, all tests shall be conducted with conductors stripped to the minimum length.

9.1.6.4 For a connector intended to receive only one conductor in an opening, when the strip length is not marked on the connector, the carton, or the information sheet, the insulation of the test conductor shall be stripped to allow the conductor to make contact with the full available length of the connector that contains the securing means. The conductor shall be positioned so that 6.4 – 12.7 mm (1/4 – 1/2 in) of bare conductor is exposed between the conductor-entry face of the connector and the beginning of the insulation. If the conductor projects through the wire connector without interference, the conductor shall be installed to project not more than 6.4 mm (1/4 in).

9.1.7 Equalizer

9.1.7.1 For the current-cycling test, each stranded control conductor and each stranded conductor that has been terminated or is intended to be terminated in a test connector shall have the free end welded or brazed to an equalizer to make a thorough electrical connection for each strand. Tool-applied compression connectors without welding may be used.

Note 1: An equalizer is not required but may be used for a solid test conductor.

Note 2: Equalizers need not be used on specimens intended for any other tests, as it is necessary to insert the open end of the conductor through a bushing for the secureness test.

9.1.7.2 An equalizer shall be constructed using:

a) a short length of copper or aluminum bus having one or more holes slightly larger than the conductor;

b) a tool-applied compression connector; or

c) a pressure screw-type wire connector having an open end opposite the conductor insertion end.

9.1.7.3 The end of the conductor that projects through the equalizer shall be welded into a homogeneous mass with the bus [see 9.1.7.2 a)] or the connector [see 9.1.7.2 c)]. A wire connector used as an equalizer shall not be larger than that needed for the conductor size involved, and an equalizer bus shall not be larger than the applicable bus size indicated in Table 15. Connectors of the same type as those under test or of a type that maintains the electrical connection shall be used, provided that the connector is rated and marked AL9CU.

9.1.8 Preparation of specimens

9.1.8.1 Representative specimens of the connector shall be assembled to conductors of the proper type, length, and size and in the manner used in service. For the current-cycling test, control-conductor assemblies shall also be prepared. These control-conductor assemblies shall be wired in series with the specimens used for the current-cycling test and shall carry the same test current.

9.1.8.2 If a connector is intended for assembly by means of a specific tool, this tool shall be used in the intended manner.

9.1.8.3 If a connector is intended to be assembled to a conductor by means of more than one type of specific tool, the connector shall meet the requirements when any of the specific tools are employed in the assembly operation.

9.1.8.4 With reference to 9.1.8.3, in selecting tools for assembly of a connector to a conductor, the following features shall be considered:

a) profile, width, and depth of the connector;

b) material of connector body;

c) crimping die geometry;

d) the number of crimps; and

e) similarity of crimp forces.

9.1.8.5 If specific instructions for assembling the connector to the conductor are furnished with the connector, such instructions shall be followed in the preparation of the specimens, except that the conductor shall not be brushed or abraded and an antioxidant shall be used only if the connector is pre-filled with the antioxidant. See 10.12 d).

9.1.8.6 For a spring-action connector, the conductor shall be stripped to the appropriate length and pushed into the connector according to the manufacturer's instructions.

9.1.9 Tightening torque

9.1.9.1 The connection between the conductor and the connector shall be made before the start of the first test on any specimen set. No additional tightening shall be performed during the testing program.

9.1.9.2 The specified torque shall be applied by tightening the connection between the conductor and the connector until the specified value of torque is maintained for a minimum of 5 s.

9.1.9.3 All connectors intended for use with screwdriver type slotted heads shall be tightened to the torque values specified in Table 16. Split-bolt splicing connectors shall be tightened to the torque values specified in Table 17. Specimens prepared for the current-cycling test shall be tightened using the values of torque shown in column A. All other tests shall have the specimens prepared using the values in column B.

9.1.9.4 For a twist-on connector, the tightening torque to be used for all tests, other than the current cycling, shall be the lesser of:

a) 0.111 N·m/mm^2 (0.5 lbf-in per 1 000 circular mil area) for the total circular mil (mm^2) area of copper conductors in the combination under test plus 0.066 N·m/mm^2 (0.3 lbf-in per 1 000 circular mil area) for the total circular mil (mm^2) area of aluminum conductors in the combination under test; or

b) 0.056 N·m/mm (12 1/2 lbf-in/in) of gripping diameter as defined by the furthest two opposing points of the connector parallel to the wire entry.

9.1.9.5 For a twist-on connector, the tightening torque to be used in the current-cycling test shall be 80 percent of the value specified in 9.1.9.4.

9.1.10 Test assembly

9.1.10.1 Specimen sets and the control conductor shall be connected in series and to a current source. Equalizers shall be bolted together or to lengths of bus using the hardware specified in 9.1.10.2.

9.1.10.2 The following hardware shall be used to make the connections mentioned in 9.1.10.1. Once the initial assembly is completed, there shall be no subsequent retightening.

a) A bolt shall be plated steel, SAE Grade 2, UNC thread having a maximum standard diameter compatible with the hole or holes in the connector tang and a minimum standard length allowing at least a 2-thread projection through the nut, and the projection shall not exceed 6.4 mm (1/4 in) after assembly.

b) A single flat washer shall be used on each side of the tang-to-bus connection. These washers shall be plated steel having an SAE configuration compatible with the diameter of the bolt.

c) A nut shall be plated steel, and shall have a Class 2B, UNC thread and a hexagonal configuration.

d) Clean, dry, non-lubricated screws and bolts and nuts shall be used.

e) The assembled hardware shall be torqued to the values in Table 18.

9.1.10.3 The lengths of the busbars mentioned in 9.1.10.1 shall be the minimum necessary to provide sufficient contact area for the equalizers while maintaining the center-to-center specimen spacing specified in 9.1.10.4. The cross-sectional dimensions of the bar shall be sufficient to prohibit a test-current density in excess of 1.55 A/mm^2 (1 000 A/in^2) for copper or 1.24 A/mm^2 (800 A/in^2) for aluminum bus. See Table 15.

9.1.10.4 Individual connector/conductor specimens shall be separated by at least 457 mm (18 in) when measured center-to-center.

9.1.10.5 With reference to 9.1.10.4, the spacing may be reduced with the concurrence of those concerned.

9.1.10.6 With reference to 9.1.10.4, the spacing may be reduced to a minimum of 152 mm (6 in) if a thermal barrier is used between assemblies. The thermal barrier shall extend at least 152 mm (6 in) in a vertical direction and 25.4 mm (1 in) in a horizontal direction beyond the extremities of the connector.

9.1.10.7 Test assemblies and the control conductor shall be suspended vertically or horizontally in free air by the use of loose-fitting, non-metallic tie straps around the conductors or by suspension from the equalizers, supported in turn by non-metallic blocks. The method used shall reduce the disturbance of the test connections during handling of the specimens and reduce the transmission of tensile loads to the test connectors through test or supply conductors. See Figure 2 for an example of a vertical arrangement.

9.1.10.8 The temperature measurement location for the control conductor and connector samples shall be located a minimum of 610 mm (24 in) from the building floor, ceiling, and walls.

9.1.10.9 With reference to 9.1.10.8, the spacing need not be maintained if a solid insulating backboard separates the test samples from the building floor, ceiling, or walls. Samples shall be spaced at least 102 mm (4 in) from the insulating backboard.

9.2 Current cycling

9.2.1 Connectors intended for use with snap-on molded insulating covers or packaged with insulating materials that are intended to be wrapped around the completed connector/conductor termination shall be tested without the insulating covers or material installed.

9.2.2 Temperatures shall be measured and recorded for at least 1 cycle of each working day.

9.2.3 The current-off times may be reduced after the first 25 cycles of testing to 5 min more than the maximum time it takes any connector to reach a stable temperature during the current-off period. Forced-air cooling may be used to reduce the current-off time with the concurrence of those concerned. A test specimen has attained a stable temperature when three readings at 10 min intervals show no more than a 2 °C variation between any two of the readings. The time to temperature stabilization shall be the current-off time at which the first of three readings indicating stable temperature was recorded.

9.2.4 Temperatures shall be measured no sooner than the last 5 min of the normal current-on time. If the size of the test specimen set or the speed of the data acquisition system is such that not all measurements can be completed within the 5 min, the current-on time shall be extended as necessary to complete such measurements.

9.3 Static-heating sequence

9.3.1 Static-heating test

9.3.1.1 Specimens shall be selected and prepared as described in 8.3.2 and 9.1.8, except that equalizers shall not be used.

9.3.1.2 The test assembly and securing hardware shall be as described in 9.1.10.

9.3.2 Secureness test

9.3.2.1 Except as noted in 9.3.2.5, the set-up shall be as shown in Figure 3.

9.3.2.2 A connector shall be fastened to a length of conductor not less than 76 mm (3 in) longer than the height specified in Table 19, and shall be rigidly secured in a vertical position simulating actual service conditions. The free end of the conductor shall be passed through a bushing of the size specified in Table 19. The bushing shall be attached to an arm driven by a motor at a rate of approximately 9 rpm and in such a manner that the center of the bushing describes a circle in a horizontal plane. See Figure 3. The circle shall have a minimum diameter of 76 mm (3 in), and its center shall be vertically below the center of the conductor opening in the connector. The distance between the upper side of the bushing and the mouth of the connector shall be within 12.7 mm (1/2 in) of height specified in Table 19. The bushing shall be lubricated so there is no binding, twisting, or rotation of the insulated conductor. A mass as specified in Table 19 shall be suspended from the free end of the conductor.

9.3.2.3 For the test of a splicing connector in which the conductors lie parallel to or in line with each other, the set-up shall be as illustrated in Figure 3. If the connector is secured to conductors of different sizes, the mass shall be attached to the smallest conductor, and the entire assembly of connector, conductors, and mass shall be suspended by means of the largest conductor. The values of mass W and height H shall be selected from Table 19 according to the size of the conductor to which the mass is attached. Terminal connectors or other means that will distribute the stress uniformly among the strands of the conductor shall be employed for attaching the mass and for securing the assembly to the frame of the testing machine.

9.3.2.4 When the connector is such that the conductors are intended to extend all the way through it, the ends of the conductors not secured to the testing machine or to the mass may project not more than 6.4 mm (1/4 in) beyond the body of the connector.

9.3.2.5 A splicing connector in which the conductors do not lie parallel to or in line with each other shall be assembled to a length of through conductor and a length of tap conductor, each of the size for which the connector is intended. The assembly shall be supported by a U-shaped yoke, the arms of which grasp the through conductor on each side of the connector approximately 50 mm (2 in) from the ends of the connector. The depth of the yoke shall be approximately 76 mm (3 in). The yoke shall be secured firmly to the frame of the testing machine so that the tap conductor hangs vertically. The mass, which shall be suspended from the free end of the tap conductor after it has passed through the bushing of the testing machine, shall be as specified in Table 19 according to the size of the tap conductor. The length of the tap conductor shall be not less than 76 mm (3 in) more than the height specified in Table 19, corresponding to the size of the tap conductor. See Figure 4. The testing machine shall be operated as described in 9.3.2.2.

9.3.3 Repeated static-heating test

9.3.3.1 The sample sets previously subjected to the static-heating test and the secureness test shall be subjected to a second static-heating test as described in 9.3.1.

9.3.4 Pullout test

9.3.4.1 The same connectors and entry holes subjected to the secureness test shall be subjected to a direct pull of the applicable value specified in Table 20.

9.3.4.2 For an insulated connector in which the insulation is assembled to the connector during installation, the test shall be conducted with the insulation in place if it is always supplied with the connector by the manufacturer. Otherwise the test shall be conducted without the insulation assembled to the connector.

9.3.4.3 The pull shall be exerted by means of a tension-testing machine, dead weights, or other equivalent means so that there is no sudden application of force or jerking during the test.

Note: Breakage or tearing of the insulation of an insulated connector is allowed during the pullout test.

9.3.4.4 The connector shall be suspended from the largest conductor. Beginning with the smallest conductor, one conductor of each size of conductors in the combination shall be separately subjected to the force specified in Table 20.

Note: See Annex E for example.

9.4 Mechanical sequence

9.4.1 Secureness test

9.4.1.1 The test procedure described in 9.3.2 shall be conducted.

9.4.2 Pullout test

9.4.2.1 The test procedure described in 9.3.4 shall be conducted.

9.5 Dielectric withstand

9.5.1 General

9.5.1.1 No specimen shall be subjected to more than one dielectric-withstand test.

9.5.1.2 With reference to 9.5.1.1, with the concurrence of those concerned, the unconditioned as-received specimens used for Test A, insulation puncture (see 9.5.2) may be used for Test B, flashover (see 9.5.3).

9.5.2 Test A, Insulation puncture

9.5.2.1 Three specimen sets shall be subjected to this testing, in the as-received condition, conditioned in accordance with 9.5.2.2 and 9.5.2.3.

9.5.2.2 Specimens previously assembled to conductors shall be conditioned in an air-circulating oven at an elevated temperature corresponding to the insulation temperature rating, according to Table 21.

9.5.2.3 The specimens not previously assembled to conductors shall be conditioned for 168 h in an air-circulating oven at 100 °C. Connectors employing extended covers or sleeves may have the wires pre-installed, but not crimped, prior to the oven aging. The specimens shall then be allowed to cool to room temperature. Following the oven conditioning, the specimens having insulation of hygroscopic material, such as nylon, shall be conditioned for 24 h at a relative humidity of 85 ± 5 percent at 30 ± 2 °C. The specimens shall then be assembled (or crimped) to conductors in the intended manner.

9.5.2.4 Each specimen shall be connected to a conductor(s) in the intended manner, and be subjected to a test voltage applied between the conductor(s) and an outer electrode. The test voltage shall be applied for 1 min and shall be in accordance with Table 2 based on the rated connector voltage. Puncture of conductor insulation during this test is inconclusive and shall require retesting.

9.5.2.5 Only that portion of the outer insulating surface that covers current-carrying parts shall be covered with the outer electrode. Each specimen shall be embedded in No. 7-1/2 conductive shot that is to serve as the outer electrode. A smaller than No. 7-1/2 (higher size number) shot may be used with the concurrence of those concerned. Conductive metal foil shall be used as the outer electrode for a connector that uses a separable cap that is intended to be applied after assembly of the conductors to the connector, or when a connector has openings that will allow entry of the shot.

9.5.2.6 A connector that has openings that allow the entrance of shot, potentially resulting in flashover, shall have those openings closed with tape, petrolatum, epoxy, silicone, rubber, or other suitable material. The exposed tang of a terminal connector shall be similarly treated. This supplementary insulating material shall not be applied so as to supplement the connector insulation where it covers live parts. If flashover between the electrode and a normally insulated live part occurs, the supplementary insulation may be repaired and the test repeated.

9.5.3 Test B, flashover

9.5.3.1 Each specimen shall be connected to a conductor(s) in the intended manner, and be subjected to a maximum test voltage applied between the conductor(s) and an outer electrode. The maximum test voltage specified in Table 2 shall be selected based on the rated connector voltage. Puncture of the connector insulation during this test is inconclusive and shall require retesting.

9.5.3.2 With reference to 9.5.3.1, the Test A voltage specified in 9.5.2.4 shall be applied for 1 min. The voltage shall then be rapidly and steadily increased to the maximum test voltage specified in Table 2.

9.5.3.3 With reference to 9.5.3.2, after being held at the required test voltage for 1 min, the voltage may be reduced to 0 V and then rapidly and steadily increased to the maximum test voltage.

9.5.3.4 A connector having insulation in the form of a cap shall be embedded in No. 7-1/2 conductive shot that is to serve as the outer electrode. A smaller than No 7-1/2 (higher size number) shot may be used with the concurrence of those concerned. Any other connector shall have the surface immediately adjacent to the conductor opening covered with conductive metal foil to serve as the outer electrode.

9.5.3.5 To reduce the occurrence of insulation puncture, the outer surface of the connector insulation and any exposed tang shall be supplemented with tape, petrolatum, epoxy, silicone, rubber, or other similar insulating material so that it does not interfere with the position of the outer electrode immediately adjacent to the connector opening.

9.5.4 Test C, flashover

9.5.4.1 The test voltage specified in Table 22 shall be selected based on the rated connector voltage and applied for 1 min.

9.5.4.2 Specimens shall not be assembled to conductors. The open end of the connector shall be placed on a flat metal plate in a position most likely to result in flashover. The test voltage shall be applied between the metal plate and all insulated metal parts of the connector.

9.6 Secureness of insulation

9.6.1 For other than a connector as described in 9.6.2, the insulation of a connector shall be subjected to a direct pull of 89 N (20 lb). The force shall be applied for 1 min between the insulation and the connector.

9.6.2 Connector insulation in the form of a tubular sleeve and intended for use with 10 AWG (5.3 mm^2) or smaller conductors shall be subjected to a direct pull applied for 1 min between the insulation and connector as specified in 9.6.3.

9.6.3 The test shall consist of applying:

a) a 4.4 N (1-lb) pull on the following:

1) unassembled, as-received specimens; and

2) unassembled specimens after conditioning for 168 h at 100 ± 1 °C in an air-circulating oven; cooling to room temperature; and, if made of a hygroscopic material such as nylon, conditioning for 24 h at a relative humidity of 85 ± 5% and a temperature of 30 ± 2 °C; and

b) a 22 N (5-lb) pull on the following:

1) assembled as-received specimens;

2) specimens that have been assembled to a conductor and then subjected to the oven conditioning in accordance with Table 21; and

3) specimens that have been assembled to a conductor after conditioning for 168 h at 100 ± 1 °C in an air-circulating oven, cooling to room temperature, and, if made of a hygroscopic material such as nylon, conditioning for 24 h at a relative humidity of 85 ± 5% and a temperature of 30 ± 2 °C.

9.6.4 The pull shall be exerted by means of a tension-testing machine, dead weights, or other equivalent means so that there is no sudden application of force or jerking during the test.

9.6.5 A temporary distortion of flexible insulating material during the test shall be allowed. Tearing or breaking of the insulation shall be allowed, provided that the connector complies with the dielectric-withstand test when retested. The variety of designs of connectors is such that it is not practicable to specify in detail how to apply the pull. The arrangement shall be such that the tendency for the insulation to be damaged or to be separated from the body is greatest.

9.6.6 A connector having flexible insulation that is assembled to the body of the connector after the latter is assembled to a conductor or conductors shall not be subjected to the test specified in 9.6.1 and 9.6.2 until after the insulation has regained its normal shape after being assembled to the connector.

9.7 Flexing

9.7.1 The flexing test shall be conducted on insulating covers in the as-received condition, after oven conditioning to an elevated temperature corresponding to the insulation temperature ratings as specified in Table 21, and after conditioning at minus 10 °C for 2 h. The specimens conditioned at minus 10 °C shall be allowed to attain room temperature after removal from the cold chamber before flexing is conducted.

9.7.2 The cover shall be completely opened and closed 20 times. If flexible extensions are provided around the conductors, the conductors shall also be flexed 20 times. Distortion of the flexible extensions shall be allowed if, after 24 h, they return to their original shape and position.

9.8 Low temperature installation

9.8.1 In Canada, the connectors, short lengths of insulated wires, and the applicable hand or ratchet tools shall be placed in a cold chamber for 1 h to allow all of the parts to reach a uniform temperature of 0 ± 1 °C. The installation of the connectors on the wires shall be performed in the cold chamber and the specimens shall be removed from the cold chamber and immediately examined for any evidence of damage.

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

9.9 Moisture absorption

9.9.1 Specimens used for the moisture-absorption test shall be clean and dry. The insulation of each connector shall be broken, weighed, and then submerged in distilled water at room temperature for 24 h. After removal from the water, the specimens shall be dried with a soft cloth to remove all surface water before reweighing.

9.10 Stress corrosion/moist ammonia (NH_4)

9.10.1 Each test specimen shall be subjected to the physical stresses normally imposed on or within a part as the result of assembly. Such stresses shall be applied to the specimens prior to and during the test. Specimens shall be assembled to a 152 mm (6 in) length of the maximum rated size conductor and torqued to the value specified in 9.1.9.3.

9.10.2 The specimens shall be degreased and then continuously exposed in a set position for 10 d to a moist ammonia-air mixture maintained in a glass chamber approximately 305 by 305 by 305 mm (12 by 12 by 12 in) having a glass cover.

9.10.3 Approximately 600 ml of aqueous ammonia having a specific gravity of 0.94 shall be maintained at the bottom of the glass chamber below the specimens. The specimens shall be positioned 38 mm (1-1/2 in) above the aqueous ammonia solution and supported by an inert tray. The moist ammonia-air mixture in the chamber shall be maintained at atmospheric pressure and a temperature of 34 ± 2 °C.

9.11 Stress corrosion/mercurous nitrate ($HgNO_3$)

9.11.1 Specimens shall be immersed in an aqueous solution of 100 g of mercurous nitrate and 13 ml of nitric acid (specific gravity of 1.42) per liter for 15 min. Evidence of cracking shall be determined with normal or corrected vision without magnification.

9.12 Spring-action sequence

9.12.1 Conditioning

9.12.1.1 A spring-action clamp-type connector intended for reuse shall be subjected to the conditioning specified in 9.12.1.4 and subjected to the tests specified in 9.12.2 and 9.12.3.

9.12.1.2 A spring-action clamp-type connector intended for a one-time use only shall not be subjected to the conditioning specified in 9.12.1.1 and shall be subjected to the tests specified in 9.12.2 and 9.12.3. The marking for a one-time-use-only connector shall be as specified in 10.24.

9.12.1.3 Specimens shall be selected and prepared as described in 8.12 and 9.1.8.

9.12.1.4 The connectors shall be subjected to conditioning consisting of nine insertions and withdrawals of a conductor of the same size and type to be used for the tests specified in 9.12.2 and 9.12.3. A tenth insertion of a newly stripped, previously unused length of conductor shall be made and left in place for the tests in 9.12.2 and 9.12.3.

9.12.2 Temperature test

9.12.2.1 The specimens conditioned according to 9.12.1 shall be subjected to this test.

9.12.2.2 The specimens shall be connected in series and a current shall be passed through the circuit. The values of current used for this test shall be the applicable values specified in the static-heating columns of Table 6 for the conductor size and type. The test shall be run for 30 d without interruption. Temperatures shall be measured and recorded every 24 h.

9.12.2.3 Upon completion of this test, the connector shall be subjected to the test specified in 9.12.3.

9.12.3 Dielectric-withstand test

9.12.3.1 The specimens that have been previously subjected to the test specified in 9.12.2 shall be used for this test. The connector surface shall be wrapped in foil and serve as the outer electrode.

9.12.3.2 A test voltage of 1 000 V plus twice the rated voltage of the connector shall be applied between:

a) live parts that are not conductively interconnected; and

b) live parts and the metal foil that serves as the outer electrode.

9.12.3.3 To determine that a spring-action connector complies with 9.12.3.2, the connector shall be tested by means of a transformer having suitable capacity whose output voltage is essentially sinusoidal and can be varied. The applied potential shall be increased from zero until the required test level is reached, and shall be held at that level for 1 min. The increase in the applied potential shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

9.13 Over-torque

9.13.1 A connector where the torque is applied by means of a blade-type screwdriver shall be assembled to a hardened steel rod. The rod shall be fully inserted into the connector. The diameter of the rod shall be one-half the conductor opening of the connector, as measured perpendicular to the axis of the screw.

9.13.2 If the connector uses a headless screw, the width of the screwdriver blade shall be at least 90 percent – but not more than 100 percent – of the minor diameter of the screw. If the connector uses a headed screw, the width of the blade shall not be less than the diameter of the head.

9.13.3 A tightening torque as specified in Table 23 shall be applied for 5 s.

9.14 Separable part securement

9.14.1 Each test specimen shall be subjected to a minimum direct pull of 44.5 N (10 lb) for 1 min between the separable insulating parts of insulation in the direction most likely to cause separation.

9.14.2 The variety of designs of connectors is such that it is not practicable to specify in detail how to apply the pull. The arrangement shall be such that the tendency for the insulation to become separated is the greatest.

Note: Drilling small holes in each part and looping small piano wire through these openings for subsequent attachment to tensile testing equipment has been found to be an effective method.

10 Marking, labeling, and packaging

Advisory Note: *In Canada, there are two official languages, English and French. Markings required by this standard may have to be provided in other languages to conform with the language requirements where the product is to be used.*

10.1 Required marking locations shall be in accordance with 10.2 – 10.24. Refer to Annex F as a guide to marking locations.

10.2 A connector shall be legibly marked with:

a) the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product is identified;

b) a distinctive catalog number or the equivalent; and

c) the conductor size or range of sizes. The conductor size or range of sizes shall be marked on the unit container of a connector that accommodates two or more conductors in the same opening.

10.3 In lieu of the markings in 10.2 b) or c), or both, a connector shall be marked with a single identifying symbol. This symbol may be an individual catalog number, a type designation, a size designation, such as 12, or an equivalently significant symbol. Each unit container containing connectors so identified or an information sheet packed in the unit container shall be marked with the information specified in 10.2 a), b), and c). A type designation is intended primarily to identify a particular design, which may include various features covered by different catalog numbers.

10.4 A connector that accommodates a single conductor in an opening shall be marked with the following or equivalent wording, as applicable:

a) "CU" for copper conductor only;

b) "AL" for aluminum conductor only;

c) "AL-CU" or "CU-AL" for aluminum, copper-clad aluminum, and copper conductor;

d) for an insulated connector, the marked voltage rating shall be: "300 volts maximum", "600 volts maximum", or "600 volts maximum, building wiring; 1000 volts maximum, signs or luminaires". The marking may be on the unit container or on an information sheet packed in the unit container; and

e) the operating temperature rating for which the insulated connector has been found capable of being used. See also 10.14 d).

10.5 The unit container or an information sheet packed in the unit container of a connector that accommodates two or more conductors in the same opening shall be marked with the following or equivalent wording, as applicable:

a) "CU " for copper conductor only;

b) "AL " for aluminum conductor only;

c) "AL-CU " or "CU-AL " for copper to copper, or copper-clad aluminum to copper-clad aluminum, or aluminum to aluminum conductor, but not intermixed;

d) "AL-CU (intermixed – dry locations)" or "CU-AL (intermixed – dry locations)" for copper to aluminum conductor; for copper-clad aluminum to copper; and for copper-clad aluminum to aluminum;

e) for an insulated connector, the marked voltage rating shall be: "300 volts maximum", "600 volts maximum", or "600 volts maximum, building wiring; 1000 volts maximum, signs or luminaires". The marking may be on the unit container or on an information sheet packed in the unit container;

f) with the operating temperature rating for which the insulated connector has been found capable of being used. See also 10.14 d); and

g) with the complete or a partial list of intended conductor combinations.

10.6 The following words shall also appear on or in the unit container: "TO BE SOLD ONLY WITH INSTALLATION INSTRUCTIONS".

10.7 If a connector is intended for use with aluminum conductor of one size or range of sizes and with copper conductor of a different size or range of sizes, the conductor-size marking shall clearly differentiate the size or range of sizes of the conductors for which the connector is rated.

10.8 A connector tested with solid or stranded conductor other than as indicated in 8.1.3 shall be marked ″Solid ″ or ″Stranded ″ or with both markings as applicable. See 10.9.

10.9 The ″Solid″ and ″Stranded″ markings specified in 10.8 may be:

a) abbreviated ″Sol″ and ″Str″ respectively; or

b) provided on the unit container or on an information sheet packed in the unit container, if there is insufficient space on the connector for either the complete or the abbreviated marking.

10.10 A connector, a unit container, or an information sheet packed in the unit container for a connector tested with conductors other than Class B, SIW, or Class C stranding [see 1.2 f) and 9.1.5.3] shall also be marked with the conductor class or classes and the number of strands.

10.11 Unless any rearrangement or adjustment of a connector that is necessary to adapt it to various sizes of conductor is obvious, it shall be clearly indicated by size markings or other instructions appearing on:

a) the connector;

b) its unit container; or

c) an information sheet packed in the unit container.

10.12 A procedure that must be followed for proper assembly of a wire connector to a conductor shall be provided as follows:

a) USE OF A SPECIFIC TOOL REQUIRED: If a connector is intended to be assembled to a conductor(s) by a specific tool, the tool designation or the designation of a removable tool part, such as a pressing die, shall be marked on the connector, or on or within the unit container in which the connector is packed. The marking shall be by at least one of the following means:

1) catalog or type designation;

2) color coding;

3) die index number; or

4) other equivalent means.

b) MULTIPLE CRIMPING OPERATIONS: Information shall appear either:

1) on the unit container in which the connector is packed;

2) on the tool or pressing die that must be used for its application;

3) on the carrying case provided for permanent storage of the tool and dies; or

4) on the connector.

Location of the crimping points only, without additional instructions, may be marked on the connector if the additional required information is located as indicated in Item 1), 2), or 3)

c) CONDUCTOR STRIP LENGTH: Strip length marking as specified in Table 14 shall appear:

1) on the connector;

2) on the unit container or on an information sheet contained therein;

3) on an insulating cover; or

4) on the tool or on the carrying case provided for its permanent storage if:

i) the connector requires the use of a specific tool for its application; and

ii) the strip length applies to all insulated connectors with which the tool is used.

d) PRELIMINARY PREPARATION OF CONDUCTOR REQUIRED: Instructions for preparation of the conductors, such as use of compound or twisting conductors together before assembly, shall appear on the unit container or an information sheet packed in the unit container.

10.13 A unit container or an information sheet shall be marked with:

a) the manufacturer's name; and

b) a distinctive catalog number of the connector or the equivalent if the marking is provided as specified in 10.17.

10.14 A separable cover of a splicing connector shall be marked with:

a) the manufacturer's name;

b) a distinctive catalog number or the equivalent;

c) the voltage rating; and

d) the operating-temperature limit (see also 10.4, 10.5 and Table 1).

10.15 The operating temperature limit specified in 10.14 d) is not required to be marked for a ceramic, twist-on connector.

10.16 The voltage rating [see 10.14 c)] and operating-temperature limit [see 10.14 d)] may be marked on the unit container when such container is also marked as specified in 10.14 a) and b).

10.17 The information in a marking shall not be divided between a unit container and an information sheet. If any of the required markings are placed either on the unit container or on the information sheet packed in the unit container, rather than on the connector, then all applicable markings as specified in the clauses in their entirety shall be so placed.

10.18 A tool-applied crimp-on connector for multiple conductors shall be marked with the following or equivalent: ″Pre-twist Wires Before Crimping.″ Illustrations showing multiple twisting internal to the body of the connector may be used when used in conjunction with the marking. See 10.17. A connector that does not lend itself to direct contact, such as a butt-end splice connector, shall not be required to be marked. A connector that has a C or H configuration or permits a conductor to be directly laid into the opening shall not be required to be marked.

10.19 A connector tested according to 7.1.3 shall be marked with the letters ″OEM″. When marketed for field-wiring applications, the marking described in 10.18 is still required. See 10.17. An OEM connector shall have the following included in the information sheet or unit container: ″A connector designated as an OEM (Original Equipment Manufacturer) connector does not require pre-twisting when used in OEM applications.″

10.20 A tool-applied crimp-on connector for CU-AL direct contact intermix dry locations, which has been tested to the requirements of this standard without pre-twisting of conductors, need not be marked ″Pre-twist Wires Before Crimping.″

10.21 A connector additionally rated for use with metric conductors shall have the metric wire range marked in close proximity to the rated AWG wire range on the connector, unit container, or information sheet within the unit container.

10.22 A connector rated for use with specific metric conductors shall be marked in close proximity to the metric wire range marking with the following, as applicable:

a) the letter ″r″ for rigid solid and rigid stranded; or

b) the letter ″f″ for flexible.

A connector rated for both rigid and flexible conductors need not be marked.

10.23 The flammability classification of the insulating material may be marked on the connector, smallest unit container, or on an information sheet placed in the smallest unit container. See 6.3.7.

10.24 For a spring-action type connector intended for one-time use only, the connector, unit container, or an information sheet packaged in the unit container shall be marked ″One-Time Use Only – Do Not Reuse″ or the equivalent.

Note: *Connectors when used with specified sizes and/or types of conductors may be designated as reuseable while other sizes and/or types of conductors can result in the connector being designated as non-reuseable. When this occurs, the markings for reuse or non reuse may be clearly associated with that specific wire size/range or conductor type by close proximity.*

Table 1 – Operating temperature ratings of connector insulation materials

(Clauses 6.3.5 and 10.14)

Material	Temperature, °C
Thermoplastic[a]	75 90 105 125 150
Phenolic[b]	150
Urea[c]	100
Melamine[d]	130
Melamine[e]	150

[a] Assigned by the manufacturer.

[b] Composition may be filled or unfilled.

[c] Unless the compound has been found by test to be acceptable for use at a higher temperature.

[d] Composition with a specific gravity less than 1.55.

[e] Composition with a specific gravity 1.55 or more. Compound may have cellulosic filler material.

Table 2 – Insulation puncture and flashover test voltages, Tests A and B

(Clauses 6.3.6, 9.5.2.4, 9.5.3.1, and 9.5.3.2)

Connector insulation voltage rating, V	Test voltage, Vac	
	Puncture (1 min)	Flashover (maximum)
300	2 200	4 000
600 (1 000 in signs and luminaires)	3 400	8 000

Table 3 – Test sequences – all connectors

(Clauses 7.1.1 and 8.1.2)

Clause	Test
9.2	Current cycling
	Static-heating sequence
9.3.1	– Static heating
9.3.2	– Secureness
9.3.3	– Repeated static heating
9.3.4	– Pullout
	Mechanical sequence
9.4.1	– Secureness
9.4.2	– Pullout
9.10	Stress corrosion/moist ammonia NH_4
9.11	Stress corrosion/mercurous nitrate ($HgNO_3$)
	Spring-action clamp sequence
9.12.1	– Conditioning
9.12.2	– Temperature
9.12.3	– Dielectric withstand
9.13	Over-torque

Table 4 – Additional test sequences for insulated connectors or connectors employing insulating covers

(Clauses 7.1.1 and 8.1.2)

Clause	Test
9.5	Dielectric withstand
9.6	Secureness of insulation
9.7	Flexing
9.8	Installation at low temperature
9.9	Moisture absorption

Table 5 – Conductor material to be used in test sequences

(Clauses 7.1.10 and 8.2.5)

Conductor for which connector is intended	Conductor used in test sequences
Copper[a]	Copper
Aluminum[a]	Aluminum
Copper-clad aluminum	Copper-clad aluminum
Copper to copper[b]	Copper
Aluminum to aluminum[b]	Aluminum
Copper-clad aluminum to copper-clad aluminum[b]	Copper-clad aluminum
Copper to aluminum[b], intermixed	Copper to aluminum
Copper to copper-clad aluminum, intermixed	Copper to copper-clad to aluminum
Notes: 1) Any conductor material may be used for the dielectric voltage-withstand test sequence. 2) If a connector is rated for copper to copper, aluminum to aluminum, and copper to aluminum (intermixed), the mechanical sequence with copper to aluminum conductor may be omitted. 3) In all test sequences, aluminum conductor represents tests with copper-clad aluminum conductor.	
[a] Single conductor in an opening. [b] Two or more conductors in an opening.	

Table 6 – Test current, A

(Clauses 7.2.1, 7.3.1, 8.2.6, and 9.12.2.2)

Conductor size		Copper		Aluminum/Copper-clad aluminum	
AWG	(mm^2)	Static heating	Current cycling	Static heating	Current cycling
30	(0.05)	3.0	3.5	–	–
28	(0.08)	3.5	4	–	–
26	(0.13)	5.5	6	–	–
24	(0.20)	7	8	–	–
22	(0.32)	9	12	–	–
20	(0.52)	12	16	–	–
18	(0.82)	17	19	–	–
16	(1.3)	18	20	–	–
14	(2.1)	30	33	–	–
12	(3.3)	35	39	30	43
10	(5.3)	50	56	40	60
8	(8.4)	70	80	55	77
6	(13.3)	95	105	75	102

Table 7 – Dielectric-withstand test sequence

(Clause 7.5.1)

Connector	Required test
1. A connector having insulation in the form of a tubular sleeve and intended to accommodate only one conductor in each opening[a] and intended for use with:	
a) 10 AWG (5.3 mm^2) or smaller conductors; or	A, C
b) 8 – 6 AWG (8.4 – 13.3 mm^2) conductors.	A
2. Connectors having insulation in other than a tubular form and for conductor size not covered in item 1[b].	A, B
Notes: *A – Test A is described in 9.5.2.* *B – Test B is described in 9.5.3.* *C – Test C is described in 9.5.4.*	
[a] These types of connectors included insulation-piercing and push-in types. [b] These types of connectors include twist-on types.	

Table 8 – Minimum number of specimens for test

(Clauses 8.1.1, 8.2.1, 8.3.1, 8.4.1, 8.5.1, 8.6.1, 8.7.1, 8.8.1, 8.9.1, 8.10.1, 8.11.1, 8.12.1, 8.13.1 and 8.14.1)

Clause	Test	Number of specimens
9.2	Current cycling	4 of each combination of connector and test conductor(s)
9.3	Static-heating sequence	4 of each combination of connector and test conductor(s)
9.4	Mechanical sequence	2 of each combination of connector and test conductor(s)
	Dielectric withstand	
	Thermosetting, e.g., porcelain, cold-molded melamine, phenolic, or urea-compound	
9.5.2	– Test A - as received	12[a]
9.5.3	– Test B - as received	12[a]
9.5.4	– Test C - as received	12[a]
	Thermoplastic, e.g., vinyl or nylon	
9.5.2	– Test A – as received	12[a]
9.5.2	– Test A – after oven conditioning with specimens assembled to conductor before such conditioning	12[a]
9.5.2	– Test A – after oven conditioning with specimens assembled to conductor after such conditioning	12[a]
9.5.3	– Test B - as received	12[a]
9.5.4	– Test C - as received	6
	Secureness of insulation	
9.6.1	As received	6
9.6.3(a)	a) Unassembled	
	– as received	6
	– after oven conditioning	6
9.6.3(b)	b) Assembled	
	– as received	12[a]
	– connected to a conductor before oven conditioning	12[a]
	– connected to a conductor after oven conditioning	12[a]

Table 8 – Minimum number of specimens for test Continued on Next Page

Table 8 – Minimum number of specimens for test Continued

Clause	Test	Number of specimens
9.7	Flexing – as received – after oven conditioning – after oven conditioning – after cold conditioning	 6[b] 6[b] 6[b] 6[b]
9.8	Low temperature installation	12[a]
9.9	Moisture absorption	3
9.10 or 9.11	Stress corrosion/moist NH_4 or Stress corrosion/mercurous nitrate ($HgNO_3$)	3
9.12	Spring-action clamp sequence	6 of each combination of connector and test conductor(s)
9.13	Over-torque	6
9.14	Separable part securement	6

[a] Six specimens with maximum conductor size and six specimens with minimum conductor size.

[b] Test with the maximum conductor size.

Table 9 – Conductor materials

(Clauses 9.1.5.1 and 9.1.5.2)

		AWG (mm^2)	Test and control conductors
Aluminum	Solid	12 (3.31) and larger	Aluminum wire stock for use as an electrical conductor
	Stranded[a,b]	12 – 6 (3.31 – 13.3)	AA-1350 conductors, Class B, or SIW
Copper	Solid	30 – 16 (0.05 – 1.31)	Soft annealed, tinned or un-tinned
		14 (2.08) and larger	Soft annealed and un-tinned
	Stranded	30 – 16 (0.05 – 1.31)	Soft annealed, tinned or un-tinned
		14 (2.08) and larger	Soft annealed, tinned or un-tinned. The stranding shall be concentric or compressed Class B or concentric Class C[c]
Copper-clad aluminum	Solid	12 AWG (3.31) and larger	Soft annealed and untinned
	Stranded	12 – 6 AWG (3.31 – 13.3)	Soft annealed, tinned or untinned. The stranding shall be concentric or compressed Class B or concentric Class C

[a] Conductors of AA-8000 series alloy conductor material shall not be used for testing purposes.

[b] The hardness of the alloy and iron content is not specified.

[c] In Canada and Mexico, 8 AWG (8.4 mm^2) and larger compact-stranded copper conductors shall be used.

Table 10 – Conductor insulation

(Clause 9.1.5.1)

		AWG (mm^2)	Type of insulation
Aluminum	Solid and Stranded	12 (3.31) and larger	THHN or T90 THW or TW75 RW90 (1000V) or USE RW90 (600V) or XHHW
Copper	Solid and Stranded	30 – 24 (0.05 – 0.20)	Black thermoplastic at least 0.254 mm (0.010 in) thick[a]
		22 – 16 (0.32 – 1.31)	Black thermoplastic at least 0.762 mm (0.030 in) thick[a]
		14 (2.08) and larger	T90 or THHN THW or TW75 RW90 (1000V) or USE RW90 (600V) or XHHW
Copper-clad aluminum	Solid and stranded	12 (3.31) and larger	THHN THW USE XHHW

[a] Other colors may be used; see 9.1.5.4.

Table 11 – Conductor stranding

(Clause 9.1.5.1)

Size of conductor to which connector is to be assembled		Number of strands, if stranded conductor				
AWG	(mm^2)	Copper		Aluminum	Copper-clad aluminum	
		Class B	Class C	Class B	Class B	Class C
30 – 24	(0.05 – 0.20)	a	–	–	–	–
22	(0.32)	7	–	–	–	–
20	(0.52)	10	–	–	–	–
18	(0.82)	16	–	–	–	–
16	(1.3)	26	–	–	–	–
14 – 6	(2.1 – 13.3)	7	19	7[b]	7[b]	19[b]

[a] Number of strands may vary.

[b] Aluminum and copper-clad aluminum 14 AWG (2.1 mm^2) is not available.

Table 12 – Test conductor length

(Clause 9.1.5.6)

Conductor size		Minimum conductor length[a]	
AWG	(mm^2)	mm	(in)
30 – 8	(0.05 – 8.4)	203	(8)
6	(13.3)	305	(12)
[a] The conductor length for the secureness test in the mechanical or static-heating sequence shall not be less than that specified in 9.3.2.2.			

Table 13 – Strip-length tolerances for conductors

(Clause 9.1.6.2)

Conductor size		Tolerance	
AWG	(mm^2)	mm	(in)
30 – 14	(0.05 – 2.1)	±0.8	(±1/32)
12 – 10	(3.3 – 5.3)	±1.2	(±3/64)
8 – 6	(8.4 – 13.3)	±1.6	(±1/16)

Table 14 – Wire strip length

(Clauses 9.1.6.3 and 10.12)

Connector type	Required wire strip length marking	
	Maximum strip length	Minimum strip length
Insulated	X[a,b]	X[a,b,c]
Non-insulated	–	X[a,b,c]
Note: *An X indicates marking is required.*		
[a] Strip length shall be specified as a single nominal value if tested as specified in 9.1.6.2.		
[b] Strip length marking shall be optional if the connector is provided with an open end opposite the conductor insertion end through which the end of the conductor is visible after it is connected.		
[c] Strip length marking shall be optional if the connector is provided with an inspection hole opposite the conductor insertion end through which the end of the conductor is visible after it is connected.		

Table 15 – Busbar dimensions

(Clauses 9.1.7.3 and 9.1.10.3)

Range of test current, A	Maximum cross-section, mm (in)			
	Copper		Aluminum	
0 – 50	3.2 x 12.7	(1/8 x 1/2)	3.2 x 12.7	(1/8 x 1/2)
51 – 125	3.2 x 25	(1/8 x 1)	3.2 x 32	(1/8 x 1-1/4)

Table 16 – Tightening torque for screws

(Clause 9.1.9.3)

Size or diameter of screw, mm (in)	Torque, N·m (lbf-in)			
	A		B	
4.8 diameter (No. 10) or smaller	0.55	(4.8)	0.68	(6)
6.4 (1/4)	0.72	(6.4)	0.91	(8)
7.9 (5/16) and larger	0.99	(8.8)	1.24	(11)
Note: *Use 6.4 mm size torque for M6 screws.*				

Table 17 – Tightening torque for split-bolt connectors

(Clause 9.1.9.3)

Test conductor size installed in connector		Torque, N·m (lbf-in)			
AWG	(mm^2)	A		B	
30 – 8	(0.05 – 8.4)	7.3	(65)	9.0	(80)
6	(13.3)	15.3	(135)	18.6	(165)

Table 18 – Tightening torque for connecting hardware

(Clause 9.1.10.2)

Screw or bolt size		Tightening torque	
Metric	SAE	N·m	(lbf-ft)
–	No. 8 or smaller	2	(1.5)
–	No. 10	3	(2.0)
M6	1/4	8	(6)
–	5/16	15	(11)
M10	3/8	26	(19)
–	7/16	41	(30)
M12	1/2	54	(40)
–	9/16, 5/8 or larger	75	(55)

Table 19 – Secureness test values

(Clauses 9.3.2.2, 9.3.2.3, and 9.3.2.5)

Size of conductor		Diameter of bushing hole[a, c]		Height[b]		Mass, kg (lb)			
AWG	(mm^2)	mm	(in)	mm	(in)	Copper		Aluminum/Copper-clad aluminum	
18	(0.82)	6.4	(1/4)	260	(10-1/4)	0.9	(2)	–	–
16	(1.3)	6.4	(1/4)	260	(10-1/4)	0.9	(2)	–	–
14	(2.1)	9.5	(3/8)	279	(11)	1.4	(3)	–	–
12	(3.3)	9.5	(3/8)	279	(11)	2.3	(5)	0.7	(1.5)
10	(5.3)	9.5	(3/8)	279	(11)	2.3	(5)	0.7	(1.5)
8	(8.4)	9.5	(3/8)	279	(11)	3.6	(8)	1.4	(3)
6	(13.3)	12.7	(1/2)	298	(11-3/4)	8.2	(18)	4.5	(10)

[a] If a hole with the diameter given is insufficient to accommodate the conductor without binding, a bushing having a hole of slightly large diameter shall be allowed to be used.

[b] For 12 – 6 AWG (3.3 – 13.3 mm^2) aluminum and copper-clad aluminum conductor, use 318 mm (12-1/2 in).

[c] Bushing tolerance of ±0.8 mm (±1/32 in)

Table 20 – Pullout test values

(Clauses 9.3.4.1 and 9.3.4.4)

Size of conductor		Pullout force	
AWG	(mm^2)	N	(lb)
30	(0.05)	6.7	(1-1/2)
28	(0.08)	8.9	(2)
26	(0.13)	13.4	(3)
24	(0.20)	22.3	(5)
22	(0.32)	35.6	(8)
20	(0.52)	44.5	(10)
18	(0.82)	44.5	(10)
16	(1.3)	66.7	(15)
14	(2.1)	111	(25)
12	(3.3)	155	(35)
10	(5.3)	178	(40)
8	(8.4)	200	(45)
6	(13.3)	222	(50)

Table 21 – Oven-conditioning temperatures

(Clauses 9.5.2.2, 9.6.3, and 9.7.1)

Insulation temperature rating, °C	Minimum oven temperature, °C	
	168 h test	Optional 1440 h test
60[a,b]	110	70
70[a]	113	81
75	113	81
90	121	97
105	136	113
125	158	133
150	180	158

[a] This is an additional rating for Canada. Not applicable in the United States.

[b] This is an additional rating for Mexico. Not applicable in the United States.

Table 22 – Flashover test voltage, Test C

(Clause 9.5.4.1)

Connector insulation voltage rating, V	Flashover test voltage, Vac
300	1 600
600 (1 000 in signs and luminaires)	3 000

Table 23 – Over-torque test values

(Clause 9.13.3)

Size or diameter of screw, mm (in)	Torque, N·m (lbf-in)	
4.8 (No. 10) and smaller	1.02	(9)
6.4 (1/4)	2.26	(20)
7.9 (5/16) and larger	3.39	(30)
Note: *Use 6.4 mm size torque for M6 screws.*		

Figure 1
Method for attaching thermocouples to stranded aluminum control conductors used for current-cycling tests

(Clause 9.1.3.4)

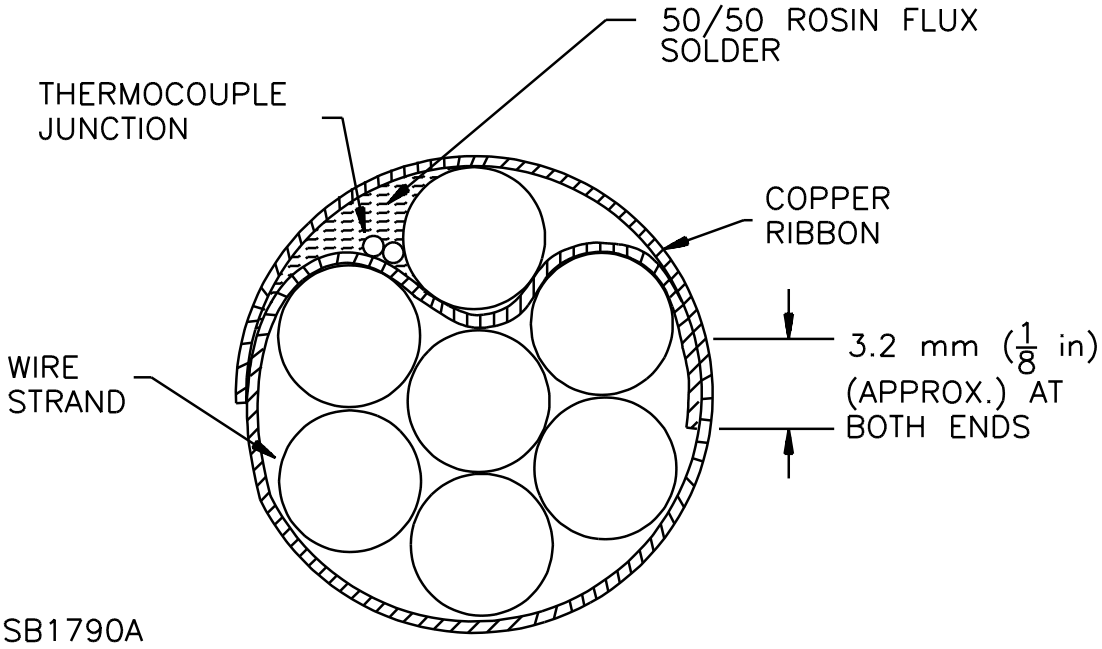
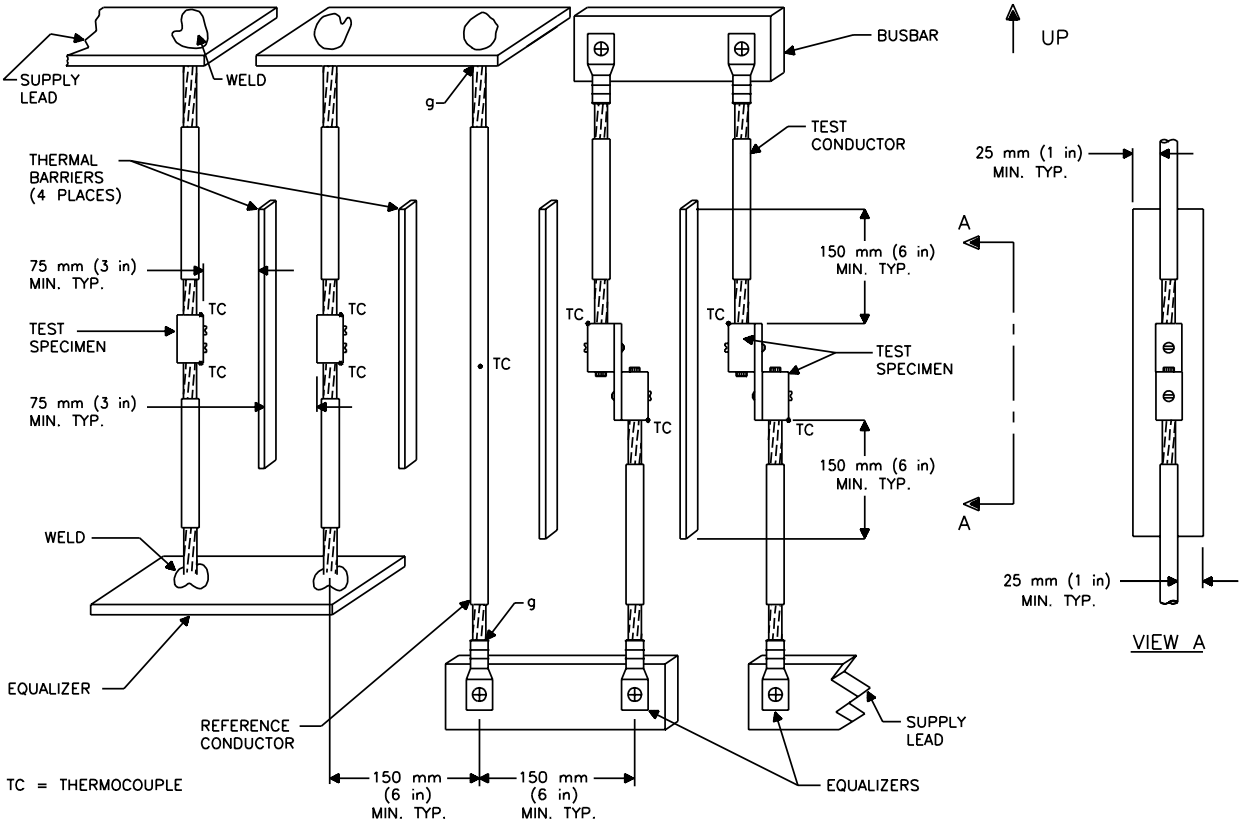


Figure 2
Vertical arrangement of specimen for current-cycling test

(Clause 9.1.10.7)



FOR A TANGLESS CONNECTOR, THE FOLLOWING INFORMATION SHALL BE PROVIDED:

a) MATERIAL OF TANG;
b) PLATING ON TANG;
c) MINIMUM CROSS-SECTION OF TANG;
d) MATERIAL OF MOUNTING SCREW;
e) USE OF A WASHER, TYPE AND SIZE;
f) TORQUE TO BE USED TO SECURE THE CONNECTOR TO THE TANG.
g) EQUALIZERS ON BOTH ENDS TO BE THE SAME TYPE (EITHER WELDED OR COMPRESSION).

SM1121B

Figure 3
Secureness test arrangement, parallel
(Clauses 9.3.2.1, 9.3.2.2, and 9.3.2.3)

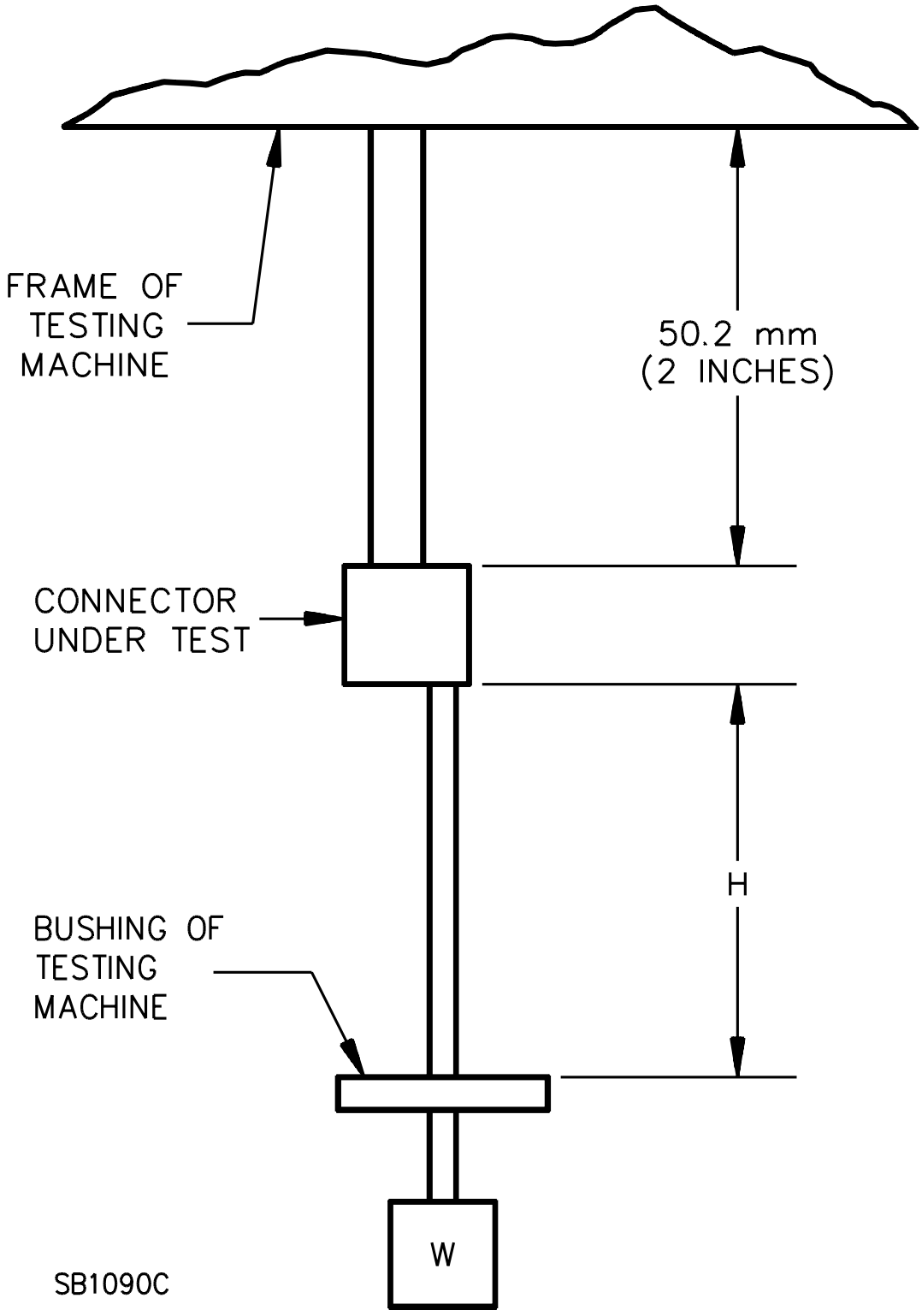
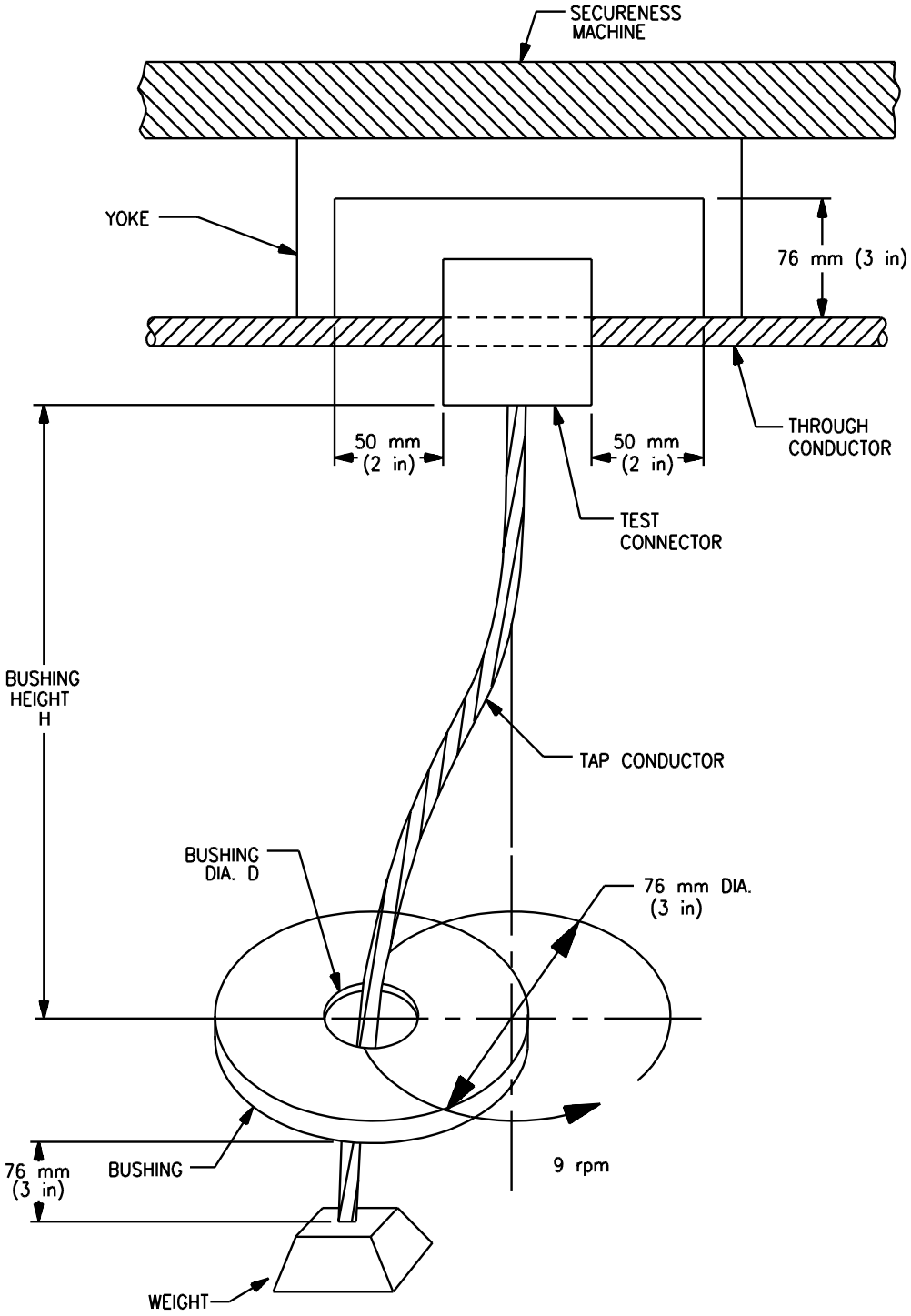


Figure 4
Secureness test arrangement, not parallel

(Clause 9.3.2.5)



Annex A – Informative references

(Informative)

(Clause 2.2.1)

A.1 The following references contain information on conductors and materials in this Standard.

ANCE Standards

NMX-J-218-ANCE
Electrical Products – Wires and Cables – Aluminum 1350 Drawing Stock for Electrical Purposes – Specifications

CSA Standards

C22.2 No. 0-10
General Requirements – Canadian Electrical Code, Part II

C22.2 No. 38-10
Thermoset Insulated Wires and Cables

C22.2 No. 75-08
Thermoplastic-Insulated Wires and Cables

UL Standards

UL 94
Tests for Flammability of Plastic Materials for Parts and Devices and Appliances

UL 746C
Polymeric Materials – Use in Electrical Equipment Evaluations

ASTM* Standards

B8-99
Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B154-95
Standard Test for Method for Mercurous Nitrate Test for Copper and Copper Alloys

B172-95
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B173-95
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

B174-95
Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors

B230/B230M-99
Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes

B231/B 231M-99
Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors

B400-94
Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors

B496-99
Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors

B566-04a
Standard Specification for Copper-Clad Aluminum Wire

B609/B 609M-99
Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes

B638-99
Standard Test Method for Tensile Properties of Plastics

IEC† Standards

IEC 60228 (2004-11)
Conductors of insulated cables

*American Society for Testing and Materials.

†International Electrotechnical Commission.

Annex B – Flammability test (material V-2 and VTM-2)

(Normative)

(Clause 6.3.7)

B.1 General

If only one specimen from a set of five specimens does not comply with the requirements, another set of five specimens shall be tested. In the case of the total number of seconds of flaming, an additional set of five specimens shall be tested if the totals are in the range of 251 – 255 s for V-2 and VTM-2.

B.2 Reference publications

B.2.1 ANCE Standards

NMX-J-192-ANCE
Electrical Products – Wires and Cables – Flame Test on Electrical Wires - Test Method

NMX-J-417-ANCE
Wires and Cables – Convection Laboratory Ovens for Evaluation of Electrical Insulation – Specifications and Test Methods

B.2.2 CSA Standard

CAN/CSA-C22.2 No. 0.17-00 (R2009)
Evaluation of Properties of Polymeric Materials

B.2.3 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

B.2.4 ASTM* Standards

D5207-98
Standard Practice for Calibration of 20 and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials

D5374-93
Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

D5423-93 (1999)
Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

* *American Society for Testing and Materials*

B.3 Apparatus

The following apparatus shall be used:

a) the apparatus described in Section 5 of UL 94, 4.1.3 and 4.1.5 of CAN/CSA-C22.2 No. 0.17, or NMX-J-192-ANCE;

b) conditioning oven as indicated by ASTM D5423 and ASTM D5374, or NMX-J-417-ANCE;

c) a desiccator containing anhydrous calcium chloride; and

d) specimen mandrel guide: 13 mm (0.5 in) diameter rod.

B.4 Test specimens

B.4.1 General

If the material is to be considered in a range of colors, melt flows, or reinforcements, specimens representing those ranges shall be provided. Specimens in the natural (if used in this color) and in the most heavily pigmented light and dark colors shall be provided and considered representative of the color range, if the burning characteristics are essentially the same. An additional set of specimens shall be provided in the heaviest organic pigment loading, unless the most heavily pigmented light and dark colors include the highest organic pigment level. When certain color pigments (for example, red, yellow, or the like) are known by experience to have particular critical effects, they shall be provided. Specimens in the extremes of the melt flows and reinforcement contents shall be provided and considered representative of the range, if the burning characteristics are essentially the same. If the burning characteristics are not essentially the same for all specimens representing the range, evaluation shall be limited only to the material in the colors, melt flows, and reinforcement contents tested, or additional specimens in intermediate colors, melt flows, and reinforcement contents shall be provided for tests.

B.4.2 V-2

Test specimens measuring 130 mm (5.0 in) in length by 13 mm (0.50 in) in width in the minimum and maximum thicknesses shall be tested, covering the thickness range to be considered. Specimens tested by this method shall be limited to a maximum thickness of 13 mm (0.50 in). Specimens in intermediate thicknesses shall be provided and may be tested if the results obtained on the minimum or maximum thickness indicate the need. Intermediate thicknesses shall not exceed increments of 3 mm (0.125 in). The specimens shall comply with the following:

a) The maximum width shall be 13 mm (0.50 in).

b) The edges shall be smooth and the radius on the corners shall not exceed 1 mm (0.05 in).

B.4.3 VTM-2

The test specimens shall be cut from the sheet material to a size 200 mm (8 in) in length by 50 mm (2 in) in width. Test specimens shall be prepared by marking a line across the specimen width, 125 mm (5 in) from one end (bottom) of the cut specimen. The longitudinal axis of the test specimen then shall be wrapped tightly around the longitudinal axis of a 13 ±1 mm (0.5 ± 0.02 in) diameter mandrel to form a lapped cylinder 200 mm (8 in) in length with the 130 mm (5 in) line exposed. The overlapping ends of the specimen shall be secured within the 76 mm (3 in) portion at the 130 mm (5 in) mark and at the upper tube section by means of pressure-sensitive tape, after which the mandrel shall be removed. If the material is prone to developing static charges, which make the formation of a cylinder difficult, the unformed specimen shall be deionized by a device or material suitable for the purpose.

Different generic materials, although capable of being wrapped and taped around the mandrel, may exhibit varying degrees of flaring out of the untaped Y-type specimen. These various forms shall be considered acceptable to test if the upper end can be formed into the cylinder.

B.5 Specimen conditioning

Specimen sets shall be conditioned as follows:

a) Sets of five specimens each shall be conditioned for at least 48 h at a temperature of 23 ± 2 °C (73 ± 3.6 °F) and a relative humidity of 50 ± 5 percent prior to testing.

b) Sets of five specimens each shall be conditioned in an air-circulating oven for 168 h at 70 ± 1 °C (158 ± 1.8 °F) and then cooled in a desiccator, over anhydrous calcium chloride, for at least 4 h at room temperature prior to testing. As an alternative to 168 h at 70 ± 1 °C, industrial laminates may be conditioned for 24 h at 125 ± 1 °C.

B.6 Test method

The burning test shall be conducted in a chamber or enclosure free of induced or forced draft.

Each specimen shall be supported by the clamp on the ring stand from the upper 6 mm (0.25 in) of the specimen, with the longitudinal axis vertical. The lower end of the specimen shall be 10 mm (0.38 in) above the top of the burner tube and 305 mm (12 in) above a horizontal layer of dry absorbent surgical cotton. To form the horizontal layer of cotton, a small portion, approximately 13 mm by 25 mm (0.50 by 1 in) shall be pulled from the supply with thumb and forefinger, and formed into a 50 mm (2 in) square having a thickness of 6 mm (0.25 in).

The flame shall be adjusted to produce a blue flame 20 mm (0.75 in) high. The method to adjust the flame is indicated in ASTM D 5207-91 or Annex A of NMX-J-192-ANCE.

The test flame shall be placed centrally under the lower end of the test specimen and allowed to remain for 10 s in the case of V-2 materials and 3 s for VTM-2 materials. For specimens that are not lapped, the flame shall be applied in line with the longitudinal axis of the specimen.

The test flame then shall be withdrawn at least 150 mm (6 in) away and the duration of flaming of the specimen noted. When flaming of the specimen ceases, the cycle shall be repeated again. If it is difficult to visually distinguish between flaming and glowing, a small piece of surgical cotton, approximately 50 mm (2 in) as described before, shall be brought into contact with the area in question. Ignition of the cotton will be indicative of flaming.

If the specimen drips molten or flaming material during either flame application, the burner may be tilted to an angle up to 45° and also slightly withdrawn from one of the 13 mm (0.50 in) sides of the specimen during the flame application, to avoid material dripping into the tube of the burner. If the specimen drips molten or flaming material or is consumed during the test, the burner shall be hand-held, and the 10 mm (0.38 in) distance between the bottom of the specimen and the top of the burner tube shall be maintained during the flame application. Any molten strings of the material shall be ignored, and the flame shall be applied to the major portion of the specimen.

The following shall be observed and recorded:

a) duration of flaming after first flame application;

b) duration of flaming after second flame application;

c) duration of flaming plus glowing after second flame application;

d) whether or not specimens burn up to the holding clamp, or up to the 130 mm (5.0 in) mark for VTM-2; and

e) whether or not specimens drip flaming particles that ignite cotton swatch.

B.7 Results

The specimens meet the requirements if:

a) no specimen burns with flaming combustion for more than 30 s after either application of the test flame;

b) total flaming combustion time does not exceed 250 s for the 10 flame applications for each set of five specimens;

c) no specimen burns with flaming or glowing combustion up to the holding clamp, or up to the 130 mm (5.0 in) bench mark for VTM-2; and

d) after the second removal of the test flame, no specimen exhibits glowing combustion persisting for more than 60 s.

The specimens may drip flaming particles that ignite the dry absorbent surgical cotton.

Annex C – Example of stability factor calculation

(Informative)

(Clause 7.2.4)

Table C.1 – Stability factor calculations

	Temperature, °C			
Cycle number	**Specimen**	**Control conductor**	**d**	**S_i**
25	130	135	-5	-6.5
50	131	136	-5	-6.5
75	133	135	-2	-3.5
100	136	135	1	-0.5
125	136	135	1	-0.5
175	138	135	3	1.5
225	139	136	3	1.5
275	138	135	3	1.5
350	141	136	5	3.5
425	142	136	6	4.5
500	142	136	6	4.5
		Sum 16 Average (D) = +1.5		

Annex D – Example of applying 8.2.2 and 8.2.3

(Informative)

(Clauses 8.2.2 and 8.2.3)

D.1 A connector intended for copper conductor only having combinations marked as follows:

a) one 10 AWG (5.3 mm^2) with one 10 AWG (5.3 mm^2), with a test current of 56 A;

b) one 12 AWG (3.3 mm^2) with one 12 AWG (3.3 mm^2), with a test current of 39 A;

c) one 14 AWG (2.1 mm^2) with one 14 AWG (2.1 mm^2), with a test current of 33 A;

d) one 16 AWG (1.3 mm^2) with one 16 AWG (1.3 mm^2), with a test current of 20 A;

e) one 10 AWG (5.3 mm^2) with three to seven 18 AWG (0.82 mm^2), with a test current of 56 A; and

f) one 12 AWG (3.3 mm^2) with four to nine 18 AWG (0.82 mm^2), with a test current of 39 A.

D.2 Specimens selected for the current-cycling test would be:

a) two 10 AWG (5.3 mm^2), with a test current of 56 A (see 8.2.2); and

b) one 10 AWG (5.3 mm^2) with three 18 AWG (0.82 mm^2), with a test current of 56 A (see 8.2.3).

Annex E – Example of applying 9.3.4.4

(Informative)

(Clause 9.3.4.4)

E.1 A connector tested for the following wire combinations are to have the sequence of pullout tests performed as follows:

a) One 12 AWG (3.3 mm^2) with three 16 AWG (1.3 mm^2): suspend the assembly by the 12 AWG (3.3 mm^2) conductor and select the 16 AWG (1.3 mm^2) conductor previously subjected to the secureness test. Apply the force onto this 16 AWG (1.3 mm^2) conductor for 1 minute.

b) One 14 AWG (2.1 mm^2) with one 16 AWG (1.3 mm^2) with two 18 AWG (0.82 mm^2): suspend the assembly by the 14 AWG (2.1 mm^2) conductor and select the 18 AWG (0.82 mm^2) conductor previously subjected to the secureness test. Apply the force onto this 18 AWG (0.82 mm^2) conductor. Hold for 1 minute and remove force. Next, select the 16 AWG (1.3 mm^2) conductor and apply the appropriate force for 1 minute.

c) Two 14 AWG (2.1 mm^2) with one 16 AWG (1.3 mm^2) with one 18 AWG (0.82 mm^2) with one 20 AWG (0.52 mm^2): suspend the assembly by one of the 14 AWG (2.1 mm^2) conductors and select the 20 AWG (0.52 mm^2) conductor. Apply the force onto this 20 AWG (0.52 mm^2) conductor. Hold for 1 minute and remove force. Next, select the 18 AWG (0.82 mm^2) conductor and apply the appropriate force. Hold for 1 minute and remove force. Next, select the 16 AWG (1.3 mm^2) conductor and apply the appropriate force. Hold for 1 minute and remove force. Lastly, select the remaining 14 AWG (2.1 mm^2) conductor and apply the appropriate force for 1 minute.

Annex F – Marking Locations Guide

(Informative)

(Clause 10.1)

Table F.1 – Marking locations

Clause	Subject[a]	Location options[a,b]
	General	
10.2 a)	Manufacturer's name or trademark	A
10.2 b)	Catalog number	A[c]
10.2 c), 10.5 g)	Conductor size or range of sizes	A[c], B
	Conductor type and connector ratings	
10.4, 10.5	Conductor material, CU	A, B
10.4, 10.5	Conductor material, AL, AL-CU, etc	A, B
10.5	Intermixing, (intermixed – dry locations)	A, B
	Stranding and other conductor types	
10.8, 10.9	Solid and/or stranded	A, B
10.10	Other conductor classes and stranding	A, B
10.21, 10.22	Metric conductors	A, B
	Miscellaneous ratings	
10.24	One time use	A, B
10.19, 10.20	″OEM″ for factory installation only	A
10.18, 10.20	″Pre-twist Wires Before Crimping″	A
10.6	″To Be Sold Only With Installation Instructions″	B
	Installation and assembly instructions	
10.12	Proper assembly procedure for connector	
a)	– Specific tool usage	A, B
b)	– Multiple crimping	A, B, C
c)	– Strip length	A, B, C, D
d)	– Preliminary preparation	B
10.11	Rearrangement/adjustment instructions to adapt to different sizes	A, B
	Insulated connectors	
10.4, 10.5, 10.16	Voltage	A, B
10.23	Flammability	A, B
10.4, 10.5, 10.15	Maximum operating temperature limit of insulation	A, B, D
10.14	Separable insulating cover	B, D
	– Manufacturer's name	
	– Catalog number or equivalent	
	– Voltage	
	– Maximum operating temperature limit	
	Unit container and information sheet	
10.13	Unit container / information sheet	B

Table F.1 – Marking locations Continued on Next Page

Table F.1 – Marking locations Continued

Clause	Subject[a]	Location options[a,b]
	– Manufacturer's name – Catalog number or equivalent	

[a] This is a brief summary of marking requirements. For complete details see the specific clause.

[b] Marking locations are coded as follows:

A. On the connector.

B. On the unit container or information sheet within the unit container. Markings shall not be divided between unit container and information sheet; see 10.17.

C. On or with the tool.

D. On the insulator.

[c] For small devices, may be replaced with an identifying symbol. See 10.3.