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Standard for Safety for Splicing Wire Connectors

Fifth Edition, Dated June 30, 2023

Summary of Topics

This Fifth Edition dated June 30, 2023 includes clarification regarding insulating covers during stress corrosion tests, the addition of Annex G – Conductor Stranding and testing with metric and non-standard size conductors.

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Commitment for Amendments

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This ANSI/UL Standard for Safety consists of the Eighth Edition. The most recent designation of ANSI/UL 486C as an American National Standard (ANSI) occurred on June 30, 2023. 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.

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Preface

This is the harmonized ANCE, CSA Group, and ULSE standard for Splicing Wire Connectors. It is the fifth edition of NMX-J-548-ANCE, the fifth edition of CSA C22.2 No. 188, and the eighth edition of UL 486C. This edition of NMX-J-548-ANCE supersedes the previous edition published May 5, 2021. This edition of CSA C22.2 No. 188 supersedes the previous edition published on May 5, 2021. This edition of UL 486C supersedes the previous edition published May 5, 2021.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), the CSA Group, and ULSE. 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.

The present Mexican standard was developed by the SC 20D – Conectores part of the CT 20 – Conductores from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the connectors manufacturers and users.

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 developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Application of 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 ULSE.

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.

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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, CSA 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 mm²) or smaller conductors;
- d) Uninsulated connectors that are used in circuits rated 8 000 V and less;
- e) Connectors intended for use in air-handling spaces; and
- f) Exothermically welded wire connectors.

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 mm²) and 10 AWG (5.3 mm²) solid;
- 2) 12 AWG (3.3 mm²) to 6 AWG (13.3 mm²) stranded, Class B concentric, compressed, and compact; and
- 3) 12 AWG (3.3 mm²) to 6 AWG (13.3 mm²) 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 mm²) 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 mm²) and 10 AWG (5.3 mm²) solid; and
 - ii) 12 AWG (3.3 mm²) to 6 AWG (13.3 mm²) stranded, Class B concentric, compressed, and Class C concentric.

c) Copper:

- 1) 30 AWG (0.05 mm²) to 10 AWG (5.3 mm²) solid; and

2) 30 AWG (0.05 mm²) to 6 AWG (13.3 mm²) stranded, Class B concentric and compressed, and Class C concentric.

d) Compact-stranded copper conductors:

In Canada and Mexico, for 8 AWG (8.4 mm²) and 6 AWG (13.3 mm²).

In the United States this is not applicable.

e) Rigid (solid and stranded) metric wire sizes, Classes 1, 2, 5, and 6, in the range of 0.5 – 10 mm², in addition to AWG sizes, with AWG ratings mandatory and metric wire ratings optional.

Note 1: Metric wire sizes are based on the IEC Standard for Conductors of Insulated Cables, IEC 60228.

Note 2: For example, a connector rated for 6 AWG (13.3 mm²) – 14 AWG (2.1 mm²) may be additionally rated for 10 – 2.5 mm². See Annex C for example.

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 2 000;
- 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, *Wires and Cables – Flame Test on Electrical Cables – Test Methods*

NMX-J-417-ANCE, *Wires and Cables – Forced-Convection Air Ovens for Evaluation of Polymeric Materials Used in Cables, Electrical Equipment and Devices – Specifications*

NMX-J-508-ANCE, *Wiring Devices – Safety Requirements – Specifications and Test Methods*

2.1.2 CSA Standards

C22.1, *Canadian Electrical Code, Part I(CE Code)*

C22.2 No. 0, *General-requirements – Canadian Electrical Code, Part II*

C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

2.1.3 IEC† Standards

IEC 60228, *Conductors of Insulated Cables*

† *International Electrotechnical Commission*

2.1.4 UL Standards

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 2043, *Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*

2.1.5 NFPA* Standards

ANSI/NFPA 70, *National Electrical Code (NEC)*

NFPA 90A, *Installation of Air-Conditioning and Ventilating Systems*

* *National Fire Protection Association*

2.1.6 NOM Standards – Mexican Secretary of Energy

NOM-001-SEDE, *Standard for Electrical Installations*

2.1.7 ULC Standards

ULC/ORD-C2043, *Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*

2.1.8 Other Codes

International Mechanical Code

Uniform Mechanical Code

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.

3.2 For conductor sizes, AWG conductor sizes are noted with their metric equivalents in parenthesis, followed by the closest metric conductor size covered by the IEC Standard for Conductors of Insulated cables, IEC 60228.

Note 1: Specifications for conductor sizes for both AWG and metric are shown as follows: 12 – 6 AWG (3.31 – 13.3) / 4.0 – 10.0 mm².

Note 2: IEC 60228 covers conductors in the metric range of 0.5 – 2 500 mm². For requirements covering AWG wire ranges outside this scope, the specification for the metric conductor will be limited to the conductor range covered by IEC 60228.

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 indenter(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/sec²

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 For products intended for use in Canada, general requirements are given in CSA C22.2 No. 0.

6.1.2 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.

6.1.3 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 [10.5](#)(d).

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 6.1](#).

Table 6.1
Operating temperature ratings of connector insulation materials

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.	

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 6.2](#).

Table 6.2
Insulation puncture and flashover test voltages, Tests A and B

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
1 000	5 000	11 000
1 500	7 000	16 000
2 000	9 000	21 000

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 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.

6.3.10 Connectors intended to be installed in air-handling spaces and marked "Suitable for Use in Air-Handling Spaces," or equivalent, as indicated in [10.25](#), shall comply with System Flammability – Discrete Components Located In Air-Handling Spaces, [7.15](#).

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 7.1](#) and [Table 7.2](#), as applicable, for the design of the connector.

Table 7.1
Test sequences – all connectors

Clause	Test
9.2	Current cycling
9.3.1 9.3.2 9.3.3 9.3.4	Static-heating sequence – Static heating – Secureness – Repeated static heating – Pullout
9.4.1 9.4.2	Mechanical sequence – Secureness – Pullout
9.10	Stress corrosion/moist ammonia NH ₄
9.11	Stress corrosion/mercurous nitrate (HgNO ₃)
9.12.1 9.12.2 9.12.3	Spring-action clamp sequence – Conditioning – Temperature – Dielectric withstand
9.13	Over-torque

Table 7.2
Additional test sequences for insulated connectors or connectors employing insulating covers

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

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 [10.12](#)(d) 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 mm²) 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 7.3](#) 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.

Table 7.3
Conductor material to be used in test sequences

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.	

7.1.11 Testing may be conducted using AWG solid and stranded sized conductors or Class 1 (rigid solid) and Class 2 (rigid stranded) metric sized conductors as follows:

- a) AWG solid conductors is representative of Class 1 metric conductors.
- b) Class 1 metric conductors is representative of AWG solid conductors.
- c) AWG stranded conductors is representative of Class 2 metric conductors.
- d) Class 2 metric conductors is representative of AWG stranded conductors.

Representative testing covers conductor sizes within the cross-sectional area envelope, as determined by the circular mils of the conductor, of the conductor sizes used as test conductors. Reference [9.1.5.5](#) – [9.1.5.6](#) for AWG stranding classes. Reference Annex [H](#) for conductor area, in circular mils, for conductor stranding, and for conductor diameters, of both AWG and metric conductor sizes.

Note: See Annex [D](#) for example.

7.1.12 A connector rated for Class 5, Class 6, or both Class 5 and 6 metric conductors (flexible stranded) shall be subjected to all test sequences using the appropriate Class of flexible metric conductors based on the ratings specified by the manufacturer. See [9.1.5.6](#) for testing with specific stranding counts.

7.1.13 Tests conducted on a connector with compact-stranded copper conductors shall be considered representative of concentric and compressed stranded copper conductors of the same size. Tests conducted on a connector with compact, compressed, or concentric-stranded aluminum conductors shall represent tests with compact, concentric, and compressed stranded aluminum conductors of the same size. See [Table 9.1](#).

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 60 Hz test current corresponding to the conductor size as specified in [Table 7.4](#). 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.

Table 7.4
Test current^a, A

Conductor size			Copper		Aluminum/Copper-clad aluminum	
AWG	(mm ²)	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	—	—
—	—	0.5	11.7	15.6	—	—
20	(0.52)	—	12	16	—	—
—	—	0.75	15.8	18.3	—	—
18	(0.82)	—	17	19	—	—
—	—	1	17.4	19.4	—	—
16	(1.3)	—	18	20	—	—
—	—	1.5	21	23.2	—	—
14	(2.1)	—	30	33	—	—
—	—	2.5	31.7	35	—	—
12	(3.3)	—	35	39	30	43
—	—	4	40.3	45	33.5	49
10	(5.3)	—	50	56	40	60
—	—	6	54.7	61.7	43.6	64
8	(8.4)	—	70	80	55	77
—	—	10	78.3	88.3	61.6	85.3
6	(13.3)	—	95	105	75	102

NOTES:
1) Values in the mm² column represent the common sizes for metric conductors, as specified in the IEC Standard for Conductors of Insulated Cables, IEC 60228. Corresponding ampacities and test currents are determined by interpolation of the values for AWG conductors, as permitted in ANSI/NFPA 70, Section 310.15(A).
2) Conductor sizes between values provided in the table may be used for testing and rating connectors. Test currents shall be determined by interpolation of adjacent conductors based on the conductor's area. Reference [Table F.1](#) for conductor area.
^a Test current shall be from a 60 Hz ac power source.

7.2.2 The current-cycling test shall be completed without any connector exceeding the following temperature rise for any recorded cycle:

- a) Tests conducted with aluminum wire with AA-1350 alloy conductors shall not exceed a 125°C temperature rise above the ambient temperature.
- b) Tests conducted with aluminum wire with AA-8000 alloy conductors shall not exceed a 115°C temperature rise above the ambient temperature.
- c) Tests conducted with copper wire shall not exceed a 125°C temperature rise above the ambient temperature.

7.2.3 The stability factor "S_i" (see [7.2.4](#)) shall not exceed the following for connector temperature measurements taken at approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles:

- a) Tests conducted with aluminum wire with AA-1350 alloy conductors shall not exceed a stability factor of ± 10 .
- b) Tests conducted with aluminum wire with AA-8000 alloy conductors shall not exceed a stability factor of ± 8 .
- c) Tests conducted with copper wire shall not exceed a stability factor of ± 10 .

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

$$S_i = d_i - D$$

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

in which:

D is the average temperature deviation;

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

d_i is a temperature deviation for an individual temperature measurement.

Note: The value for d_i is determined by subtracting the control-conductor temperature from the connector temperature. The value for d_i is a positive number when the connector temperature is more than that of the control conductor and a negative number when the connector temperature is less than that of the control conductor. The average of the 11 temperature deviations is then determined. See Annex 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 7.4](#) for the conductor size being tested until stable temperatures are reached without exceeding a 50 °C temperature rise above ambient temperature.

Note 1: A current source may be maintained at or above the required value by regulation or frequent adjustment.

Note 2: When testing with aluminum conductors, testing may be conducted with either AA-1350 or AA-8000 conductors, with the same allowed temperature rise.

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 % 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 % 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 7.5](#).

Table 7.5
Dielectric-withstand test sequence

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) / 6 mm ² or smaller conductors; or b) 8 – 6 AWG (8.4 – 13.3 mm ²) / 10 mm ² conductors.	A, C 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.	

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 % of its mass when subjected to the moisture-absorption test specified in [9.9](#).

7.10 Stress corrosion/moist ammonia (NH₄)

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 % zinc shall be tested for stress corrosion cracking.

7.10.3 A copper alloy part containing more than 15 % zinc shall show no evidence of cracking when examined using a 25X magnification after being subjected to the stress corrosion/moist ammonia (NH₄) test specified in [9.10](#).

7.11 Stress corrosion/mercurous nitrate (HgNO₃)

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 % copper shall not crack when subjected to the stress corrosion/mercurous nitrate (HgNO₃) 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](#).

7.15 System flammability compliance criteria – discrete components located in air-handling spaces

7.15.1 After being subjected to the test specified in [9.15](#), each sample set of wire connectors intended to be installed in air-handling spaces shall comply with the following parameters:

- a) The peak rate of heat release (HRRc) measured during each test shall be 100 kW or less.
- b) The peak normalized optical density measured during each test shall be 0.50 or less.
- c) The average normalized optical density (10 min test duration) shall be 0.15 or less.

8 Sampling requirements

8.1 General

8.1.1 See [Table 8.1](#) for the minimum number of specimens for test.

Table 8.1
Minimum number of specimens for test

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)
9.5.2 9.5.3 9.5.4	Dielectric withstand Thermosetting, e.g., porcelain, cold-molded melamine, phenolic, or urea-compound – Test A – as received – Test B – as received – Test C – as received	12 ^a 12 ^a 12 ^a
9.5.2 9.5.2 9.5.2 9.5.3 9.5.4	Thermoplastic, e.g., vinyl or nylon – Test A – as received – Test A – after oven conditioning with specimens assembled to conductor before such conditioning – Test A – after oven conditioning with specimens assembled to conductor after such conditioning – Test B – as received – Test C – as received	12 ^a 12 ^a 12 ^a 12 ^a 6
9.6.1 9.6.3(a) 9.6.3(b)	Secureness of insulation As received a) Unassembled – as received – after oven conditioning b) Assembled – as received – connected to a conductor before oven conditioning	6 6 6 12 ^a 12 ^a

Table 8.1 Continued on Next Page

Table 8.1 Continued

Clause	Test	Number of specimens
	– connected to a conductor after oven conditioning	12 ^a
9.7	Flexing	
	– as received	6 ^b
	– after oven conditioning	6 ^b
	– after oven conditioning	6 ^b
	– after cold conditioning	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
9.15	System flammability test – discrete components located in air- handling spaces	24
^a Six specimens with maximum conductor size and six specimens with minimum conductor size.		
^b Test with the maximum conductor size.		

8.1.2 Separate specimen sets shall be used for each of the test sequences in [Table 7.1](#) and [Table 7.2](#).

8.1.3 Specimen sets shall be tested using both solid and stranded conductors for 30 – 10 AWG (0.05 – 5.3 mm²) / 0.5 – 6 mm² sizes, and using stranded conductor for 8 AWG (8.4 mm²) / 10 mm² 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 mm²) / 2.5 – 6 mm², and these sizes are not included in the test sample selection, additional sample sets shall be tested using the maximum size solid conductor in the range of 14 – 10 AWG (2.1 – 5.3 mm²) / 2.5 – 6 mm².

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

- The largest and the smallest sizes if the line consists of four sizes or less;
- The largest, smallest, and one representative intermediate size if the line consists of five sizes; and
- 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:

- Shape of connector, shape of conductor opening, and shape and number of clamping screws;
- Material and surface treatment of the connector body, tang, clamping screw, and pressure bar;
- 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 8.1](#) 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 (mm²) / mm² 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 7.3](#), 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 7.4](#). 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 8.1](#) 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) / mm^2 size; and
- i) A single maximum AWG (mm^2) / mm^2 size conductor with a single minimum AWG (mm^2) / mm^2 size conductor.

The basic specimen set shall be in accordance with [Table 8.1](#) 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 8.1](#). 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 8.1](#) 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 8.1](#) 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 8.1](#) 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 8.1](#) shall be subjected to the moisture-absorption test specified in [9.9](#).

8.10 Stress corrosion/moist ammonia (NH₄)

8.10.1 The number of specimens identified in [Table 8.1](#) shall be subjected to the stress corrosion/moist ammonia (NH₄) test specified in [9.10](#).

8.11 Stress corrosion/mercurous nitrate (HgNO₃)

8.11.1 The number of specimens identified in [Table 8.1](#) shall be subjected to the stress corrosion/mercurous nitrate (HgNO₃) 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 8.1](#) 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 8.1](#) 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 8.1](#) shall be subjected to the separable part securement test specified in [9.14](#).

8.15 System flammability sample selection – discrete components located in air-handling spaces

8.15.1 The sample set for this test shall be the maximum number of wire connectors that will be within any 6 m (20 ft) square suspended ceiling grid area, as specified in the markings. Wire connectors shall be tested in sample sets of twenty-four (24), unless the markings for the connector identify a larger number. See [10.25](#).

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 mm²) and not smaller than 30 AWG (0.05 mm²).

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. When uninsulated wire is used, the thermocouple is not placed under any conductor insulation.

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. When using uninsulated wire, this step shall be skipped.
- 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. When using uninsulated wire, no insulation flap shall be used. A double layer of black thermoplastic tape shall be wrapped directly over the thermocouple bead.

9.1.3.4 For temperature measurements on an aluminum control conductor, if 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:

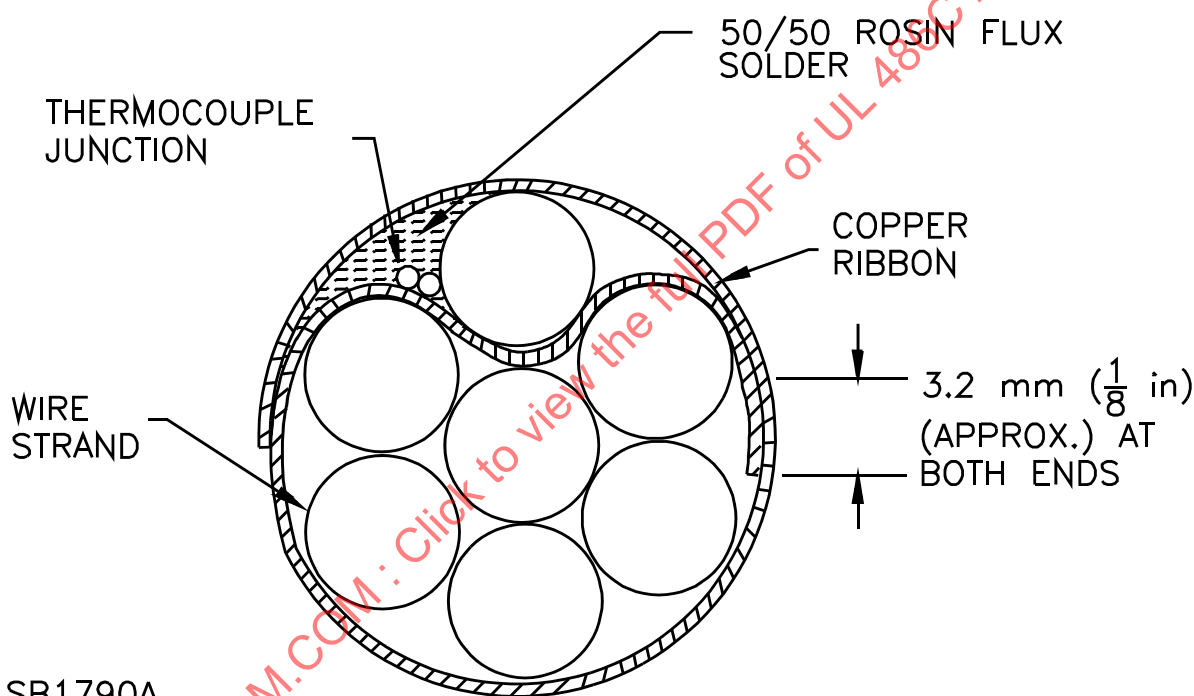
- a) A 25.4 mm (1 in) minimum length of insulation over the full circumference of the conductor shall be removed. When using uninsulated wire, this step shall be omitted.
- b) For a solid conductor, the thermocouple shall be secured to the surface of the conductor.
- c) One conductor strand shall be 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 9.1](#). 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. When using uninsulated wire, no insulation flap shall be used. A double layer of black thermoplastic tape wrapped directly over the copper ribbon or heat shrink tubing shall be used.

Figure 9.1

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



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:

- 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
- 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 9.1](#), [Table 9.2](#), [Table 9.3](#), and [Table 9.4](#). See [9.1.5.4](#). All test specimen conductors and control conductors shall be new (previously unused) or, with the concurrence of those concerned, shall be previously used conductors that have not attained a temperature of over 120 °C. 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 IEC 60228 indicates that aluminum conductors shall consist of aluminum or aluminum alloy. When testing with aluminum metric wire, alloy of the aluminum conductor shall be confirmed to be either AA-1350 or AA-8000.

9.1.5.3 When testing with copper metric wire, any conductor complying with IEC 60228 shall be considered acceptable.

9.1.5.4 With reference to [9.1.5.1](#), a connector may be tested with uninsulated conductors or conductors with any type of insulation when the connector assembly does not rely on the conductor insulation, i.e., insulation piercing connector. When using uninsulated conductors, [Table 9.2](#) shall not be applied.

9.1.5.5 In Canada and Mexico, test conductors for connectors rated for stranded copper conductors 8 – 6 AWG (8.4 – 13.3 mm²) / 10 mm² shall be Class B and compact or IEC Class 2 compact rather than concentric or compressed, as specified in [Table 9.1](#).

In the United States, this requirement does not apply.

Table 9.1
Conductor materials

		AWG (mm ²)	Test and control conductors
Aluminum	Solid	12 (3.31) / 4.0 mm ² and larger	Aluminum wire stock for use as an electrical conductor
	Stranded ^a	12 – 6 (3.31 – 13.3) / 4.0 – 10 mm ²	AA-1350 or AA-8000 conductors, Class B, or SIW
Copper	Solid	30 – 16 (0.05 – 1.31) / 0.5 – 1.5 mm ²	Soft annealed, tinned or un-tinned
		14 (2.08) / 4.0 mm ² and larger	Soft annealed and un-tinned
	Stranded	30 – 16 (0.05 – 1.31) / 0.5 – 1.5 mm ²	Soft annealed, tinned or un-tinned
		14 (2.08) / 4.0 mm ² and larger	Soft annealed, tinned or un-tinned. The stranding shall be concentric or compressed Class B or concentric Class C ^b
Copper-clad aluminum	Solid	12 AWG (3.31) / 2.5 mm ² and larger	Soft annealed and untinned
	Stranded	12 – 6 AWG (3.31 – 13.3) / 2.5 – 10 mm ²	Soft annealed, tinned or untinned. The stranding shall be concentric or compressed Class B or concentric Class C

^a The hardness of the alloy and iron content is not specified.

^b In Canada and Mexico, 8 AWG (8.4 mm²) / 10 mm² and larger compact-stranded copper conductors shall be used.

Table 9.2
Conductor insulation^a

		AWG (mm ²)	Type of insulation ^b
Aluminum	Solid and Stranded	12 (3.31) / 2.5 mm ² and larger	THHN or T90 THW or TW75 RW90 (1000V) or USE RW90 (600V) or XHHW PE or XLPE thermoset insulation
Copper	Solid and Stranded	30 – 24 (0.05 – 0.20)	Thermoplastic at least 0.254 mm (0.010 in) thick
		22 – 16 (0.32 – 1.31) / 0.5 – 1.5 mm ²	Thermoplastic at least 0.762 mm (0.030 in) thick
		14 (2.08) / 4 mm ² 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) / 2.5 mm ² and larger	THHN THW USE XHHW

^a Table 9.2 is not applicable when testing with uninsulated wire.

^b Type of insulation is not specified when testing with a connector assembly that does not rely on the conductor insulation.

Table 9.3
Conductor stranding for AWG conductors

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 mm²) is not available.

Table 9.4
Conductor stranding for Class 2 mm² conductors

Size of conductor to which connector is to be assembled		Circular		Circular compacted	
mm ²	(AWG)	Cu	Al	Cu	Al
0.5 – 1.0	(20 – 18)	7	–	–	–
1.5 – 6	(16 – 10)	7	–	6	–
10 – 16	(8 – 6)	7	7	6	6

NOTE: Stranding requirements from the IEC Standard for Conductors of Insulated Cables, IEC 60228.

9.1.5.6 A connector for flexible copper conductor other than Class B, Class C, or IEC Class 2 stranding shall be subjected to all test sequences using the class with the maximum number of strands to represent wire of that specific size with stranding counts between the tested ranges. Refer to Annex G for Conductor Stranding.

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

9.1.5.8 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.

9.1.5.9 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 9.5.

Table 9.5
Test conductor length

Conductor size			Minimum conductor length ^a	
AWG	(mm ²)	mm ²	mm	(in)
30 – 8	(0.05 – 8.4)	0.5 – 10	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.				

9.1.5.10 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 9.6. The dielectric-withstand test on an insulated connector shall be performed with conductors stripped to the marked nominal strip length.

Table 9.6
Strip-length tolerances for conductors

Conductor size			Tolerance	
AWG	(mm ²)	mm ²	mm	(in)
30 – 14	(0.05 – 2.1)	0.5 – 2.5	±0.8	(±1/32)
12 – 10	(3.3 – 5.3)	4 – 6	±1.2	(±3/64)
8 – 6	(8.4 – 13.3)	10	±1.6	(±1/16)

9.1.6.3 For an insulated connector marked with a maximum conductor strip length and a minimum conductor strip length according to [Table 9.7](#), 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.

Table 9.7
Wire strip length

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 9.8
Busbar dimensions

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)

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 9.8. 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. When a connector is tested with more than two conductors, the control conductor shall be a single conductor sized to have a test current approximately equal to, but not greater than, the test current in Table 7.4.

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.

9.1.8.7 When preparing assemblies using uninsulated conductors, a tie wrap or similar means shall be used in close proximity to the wire opening to prevent splaying or spreading of the uninsulated conductor. This restriction shall be applied to the conductor end prior to any torquing or crimping and shall remain in place during the remainder of the test.

Note: The use of a tie wrap or similar means is intended to maintain the relative positioning of the individual conductor strands with similar constraints that might occur if insulated conductors had been used, where the conductor insulation acts in the same capacity.

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 9.9](#). Split-bolt splicing connectors shall be tightened to the torque values specified in [Table 9.10](#). 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.

Table 9.9
Tightening torque for screws

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 9.10
Tightening torque for split-bolt connectors

Test conductor size installed in connector			Torque, N·m (lbf-in)	
AWG	(mm ²)	mm ²	A	B
30 – 8	(0.05 – 8.4)	0.5 – 10	7.3 (65)	9.0 (80)
6	(13.3)	–	15.3 (135)	18.6 (165)

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/mm² (0.5 lbf-in per 1 000 circular mil area) for the total circular mil (mm²) area of copper conductors in the combination under test plus 0.066 N·m/mm² (0.3 lbf-in per 1 000 circular mil area) for the total circular mil (mm²) 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 % 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 9.11](#).

Table 9.11
Tightening torque for connecting hardware

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)

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/mm² (1 000 A/in²) for copper or 1.24 A/mm² (800 A/in²) for aluminum bus. See [Table 9.8](#).

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

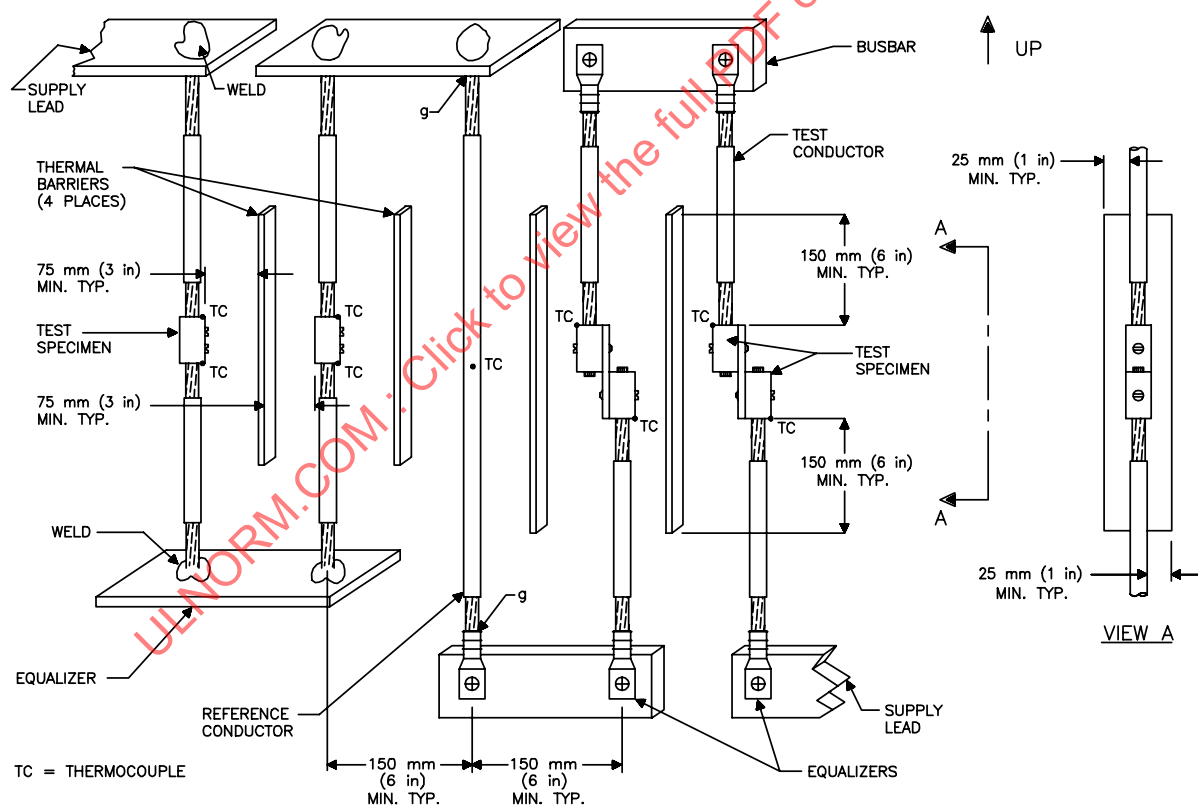
9.1.10.5 With reference to [9.1.10.4](#), the spacing may be reduced with the concurrence of those concerned.

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 9.2](#) for an example of a vertical arrangement.

Figure 9.2

Vertical arrangement of specimen for current-cycling test



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

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

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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 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. This current-off period shall be determined as follows:

- a) For all iterations of the first 25 cycles of operation, the time to stabilization for the current-off time shall be recorded.
- b) The time to current-off time stabilization during each cycle of the first 25 cycles shall be the time necessary for the test specimen to attain a stable temperature as demonstrated by three readings at 10 min intervals showing no more than a 2°C variation between any two of the readings.
- c) The current-off time for the remaining 475 cycles shall be determined by selecting the cycle with the longest interval of time for current-off time stabilization measured during the first 25 cycles of operation. The current off-time for the remaining 475 cycles shall be the first of the three readings from this longest interval of time.

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

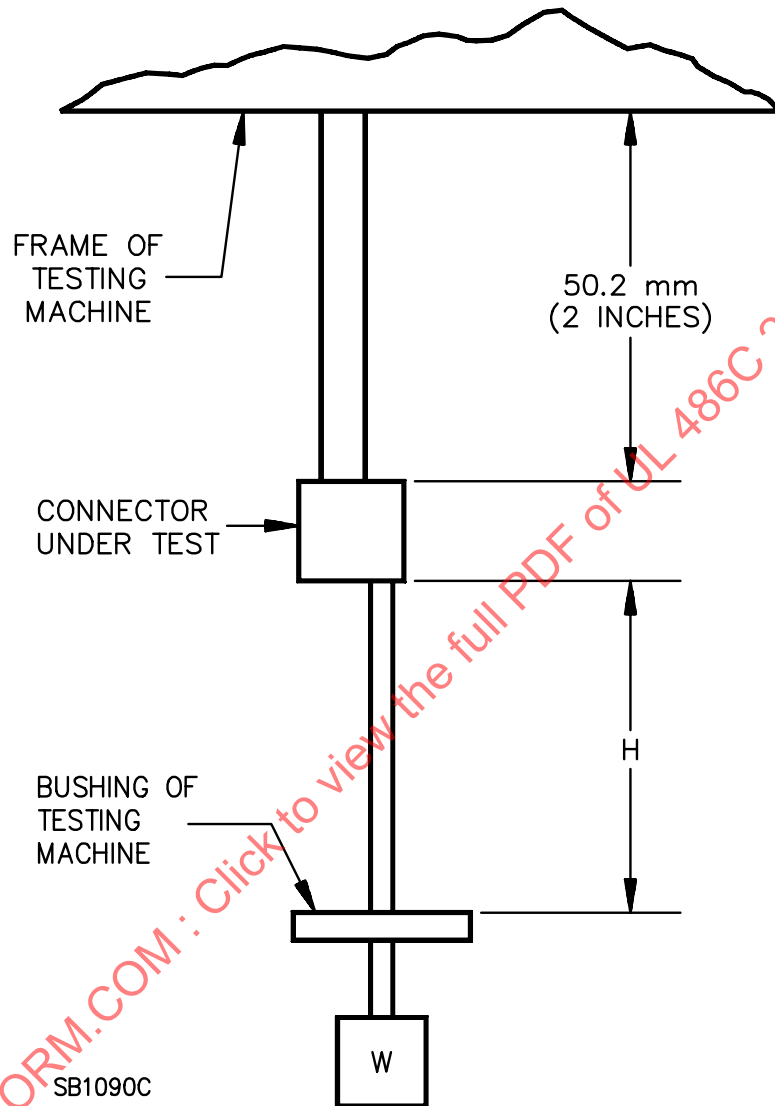
9.3.1.1 Specimens shall be selected and prepared as described in [8.3.2](#) and [9.1.8](#), except that equalizers shall not be used, as it is necessary to insert the open end of the conductor through a bushing for the secureness test. A busbar sized in accordance with [9.1.7.3](#) may be used to facilitate connection between test conductors.

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 9.3](#).

Figure 9.3
Secureness test arrangement, parallel



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 9.12](#), 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 9.12](#). 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 9.3](#). 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 9.12](#). The bushing shall be lubricated or have a hole of a slightly larger diameter than specified in [Table 9.12](#), or both, so there is no binding, twisting, or rotation of the conductor. A mass as specified in [Table 9.12](#) shall be suspended from the free end of the conductor.

Table 9.12
Secureness test values

Size of conductor		Diameter of bushing hole ^{a, c}		Height ^b		Mass, kg (lb)	
AWG (mm ²)	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)	— —
—	1.0	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)	— —
—	1.5	6.4	(1/4)	260	(10-1/4)	0.9 (2)	— —
14 (2.1)	—	9.5	(3/8)	279	(11)	1.4 (3)	— —
—	2.5	9.5	(3/8)	279	(11)	1.4 (4)	— —
12 (3.3)	—	9.5	(3/8)	279	(11)	2.3 (5)	0.7 (1.5)
—	4	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)
—	6	9.5	(3/8)	279	(11)	2.6 5.75	0.86 (2)
8 (8.4)	—	9.5	(3/8)	279	(11)	3.6 (8)	1.4 (3)
—	10	9.5	(3/8)	279	(11)	5.0 (11)	2.4 (5.25)
6 (13.3)	—	12.7	(1/2)	298	(11-3/4)	8.2 (18)	4.5 (10)
^a A slightly larger diameter bushing, or lubrication, or both, may be used to ensure there is no binding, twisting, or rotation of the conductor. See 9.3.2.2 .							
^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)							

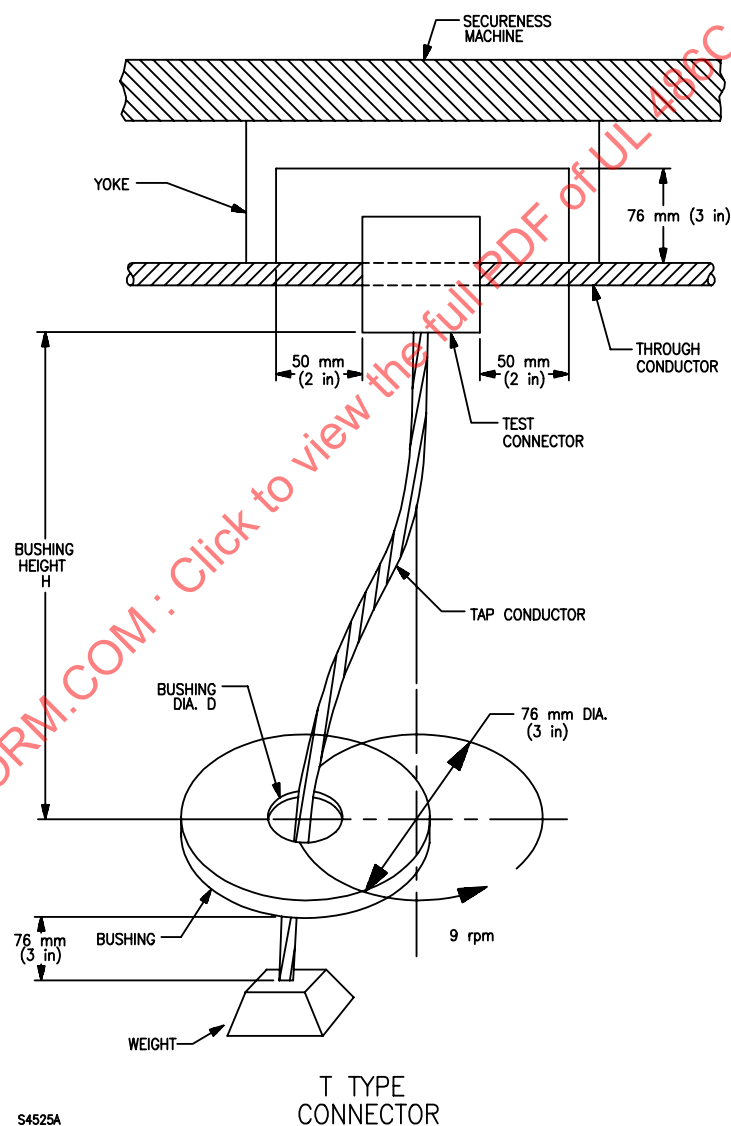
9.3.2.3 For the test of a splicing connector in which the conductors lie parallel to or in line with each other, the set-up shall be as illustrated in [Figure 9.3](#). If the connector is secured to conductors of different sizes, the mass shall be attached to the smallest conductor, and the entire assembly 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 9.12](#) 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 9.12](#) 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 9.12](#), corresponding to the size of the tap conductor. See [Figure 9.4](#). The testing machine shall be operated as described in [9.3.2.2](#).

Figure 9.4
Secureness test arrangement, not parallel



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 9.13](#).

Table 9.13
Pullout test values

Size of conductor			Pullout force	
AWG	(mm ²)	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)
—	—	0.5	43.6	(9.8)
20	(0.52)	—	44.5	(10)
—	—	0.75	44.5	(10)
18	(0.82)	—	44.5	(10)
—	—	1.0	53.4	(12)
16	(1.3)	—	66.7	(15)
—	—	1.5	77.8	(17.5)
14	(2.1)	—	111	(25)
—	—	2.5	124.6	(28)
12	(3.3)	—	155	(35)
—	—	4	163	(36.5)
10	(5.3)	—	178	(40)
—	—	6	183	(41)
8	(8.4)	—	200	(45)
—	—	10	207	(46.5)
6	(13.3)	—	222	(50)

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 9.13](#).

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 9.14](#).

Table 9.14
Oven-conditioning temperatures

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.

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 $85 \pm 5\%$ at $30 \pm 2^\circ\text{C}$. 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 6.2](#) 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 6.2](#) 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 6.2](#).

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 9.15](#) shall be selected based on the rated connector voltage and applied for 1 min.

Table 9.15
Flashover test voltage, Test C

Connector insulation voltage rating, V	Flashover test voltage, Vac
300	1 600
600 (1 000 in signs and luminaires)	3 000
1 000	4 400
1 500	6 400
2 000	8 400

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 lbf). 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 mm²) 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-lbf) 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-lbf) 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 9.14](#); 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 9.14](#), 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 minus 10 ±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 (NH₄)

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](#). Insulation that covers the copper alloy under test shall not be included as part of the test specimens.

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 (HgNO₃)

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. Insulation that covers the copper alloy under test

shall not be included as part of the test specimens. 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 [9.18](#).

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 7.4](#) 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 % – but not more than 100 % – 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 9.16](#) shall be applied for 5 s.

Table 9.16
Over-torque test values

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.

9.14 Separable part securement

9.14.1 Each test specimen shall be subjected to a minimum direct pull of 44.5 N (10 lbf) 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.

9.15 System flammability test – discrete components located in air-handling spaces

9.15.1 Wire connectors intended for use in air-handling spaces shall be subjected to the tests in:

In Canada, ULC/ORD-C2043; and

In the United States, UL 2043.

Note: Products evaluated in accordance with these requirements are considered to comply with the fire retardant and low smoke producing requirements of Section 300 of ANSI/NFPA 70, Chapter 4 of NFPA 90A, Section 602 of the International Mechanical Code, and Section 602 of the Uniform Mechanical Code.

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](#) – [10.25](#). 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", "1000 volts maximum", "1500 volts maximum", "2000 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", "1000 volts maximum", "1500 volts maximum", "2000 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 [9.1.5.5](#)] shall also be marked with the conductor class or classes.

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 (1), (2), or (3).

c) CONDUCTOR STRIP LENGTH: Strip length marking as specified in [Table 9.7](#) 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 6.1](#)).

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) "Class 1" or "Rigid Solid";
- b) "Class 2" or "Rigid Stranded";
- c) "Class 1 and 2," "Rigid Solid and Stranded," or the letter "r" for rigid solid and rigid stranded;
- d) "Class 5";
- e) "Class 6"; or
- f) "Class 5 and 6," "Flexible," or the letter "f" for flexible.

A connector rated for rigid, solid, rigid stranded, and both Class 5 and 6 flexible conductors need not be marked. "Solid" and "Stranded" may be abbreviated as "Sol" and "Str" respectively.

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.

10.25 The connector, unit container, or information sheet for a connector that has been found suitable for installation in air-handling spaces shall be marked "Suitable for Use in Air-Handling Spaces (Plenums)", or equivalent. The markings shall also state "No more than twenty-four (24) connectors are to be installed within a 6 m (20 ft) square suspended ceiling grid area" unless a larger number is tested in accordance with [8.15.1](#), in which case the larger number may be cited.

10.26 In addition to other requirements in Section [10](#), exothermically welded splicing wire connectors shall be provided with installation instructions on the unit container in which the connector is packaged or on an information sheet packed in the unit container. These installation instructions shall include the following information:

- a) Identification of all materials involved in the process;
- b) Unless provided in the form of a kit, with premeasured amounts of mixture – the recommended weight of mixture for the size and type of wires to be connected;
- c) Installer's and inspector's guide for electrical connections, which shall include the following information:
 - 1) Details regarding the preparation of all materials involved in the process; and
 - 2) Instructions on how to inspect the mold cavity (i.e., ensuring it is dry and clean) prior to use.

In lieu of the markings in [10.2](#) appearing on the wire connector, exothermically welded connectors shall be permitted to have those markings appear on the smallest unit container containing the components of the system.

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ANNEX A (Informative) – INFORMATIVE REFERENCES

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

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

ASTM B154, *Standard Test Method for Mercurous Nitrate Test for Copper and Copper Alloys*

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

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

ASTM B174, *Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors*

ASTM B230/B230M, *Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes*

ASTM B231/B231M, *Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors*

ASTM B400, *Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors*

ASTM B496, *Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors*

ASTM B566, *Standard Specification for Copper-Clad Aluminum Wire*

ASTM B609/B609M, *Standard Specification for Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes*

ASTM B638, *Standard Test Method for Tensile Properties of Plastics*

ASTM B800, *Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes – Annealed and Intermediate tempers*

ASTM B801, *Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation*

ASTM B836, *Standard Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction*

ASTM B901, *Standard Specification for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction*

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

C22.2 No. 38, *Thermoset Insulated Wires and Cables*

C22.2 No. 75, *Thermoplastic-Insulated Wires and Cables*

IEC TR 62602, *Conductors of Insulated Cables – Data for AWG and KCMIL sizes*

NMX-J-032-ANCE, *Wires and Cables – Concentric Lay Stranded Aluminum 1350 Alloy Conductors for Electrical Purposes – Specifications*

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

NMX-J-532-ANCE, *Wires and Cables – AA-8000 Series Aluminum Alloy Wire with Annealed Intermediate Tempers – Specifications*

NMX-J-533-ANCE, *Wires and Cables – AA-8000 Series Aluminum Alloy Concentric-Lay Stranded Conductors with Annealed or Intermediate Tempers – Specifications*

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

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

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