UL 486C

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Splicing Wire Connectors

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

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

Fourth Edition, Dated September 28, 2000

Revisions: This Standard contains revisions through and including October 10, 2001.

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

A change in an effective date is indicated by a note following the affected item, and giving both the previous effective date and the new date the requirement becomes effective.

The following table lists the future effective dates with the corresponding reference. The future effective dates for paragraphs 4.9, 7.2.7, 7.2.9, 25.7, 25.8, Tables 7.2, 9.1, 11.1 and 25.1, Section 24, were added/changed according to the bulletin dated December 18, 2000.

Future Effective Dates	References
October 10, 2006	Paragraphs 4.9, 7.2.7, 7.2.9, 25.7, 25.8, Tables 7.2, 9.1, 11.1, 25.1, and Section 24

The new and revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated December 18, 2000. The bulletin(s) is now obsolete and may be discarded.

The revisions dated October 10, 2001 include a reprinted title page (page1) for this Standard.

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

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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

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UL 486C

Standard for Splicing Wire Connections

First Edition – December, 1983
Second Edition – October, 1991
Third Edition – February, 1997

Fourth Edition

September 28, 2000

The most recent designation of ANSI/UL 486C as an American National Standard occurred on September 7, 2001.

This ANSI/UL Standard for Safety, which consists of the Fourth edition with revisions through October 10, 2001, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to UL-RTP Standards Department, 12 Laboratory Dr., P.O. Box 13995, Research Triangle Park, NC 27709-3995.

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.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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MARKING

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FOREWORD

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

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

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

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

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

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

INTRODUCTION

1 Scope

1.1 These requirements apply to hand- or tool-applied pressure splicing wire and cable connectors intended for use with copper, aluminum, or copper-clad aluminum insulated conductors in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 These requirements apply to splicing wire and cable connectors intended for use with any combination of the following conductors: Nos. 30 – 8 AWG (0.05 – 8.4 mm^2) solid and stranded copper, No. 6 AWG (13.3 mm^2) stranded copper, Nos. 12 – 8 AWG (3.3 – 8.4 mm^2) solid and stranded aluminum, No. 6 AWG stranded aluminum, Nos. 12 – 8 AWG solid and stranded copper-clad aluminum, and No. 6 stranded copper-clad aluminum.

1.3 These requirements also cover connectors of the types specified in 1.4 intended for use with metric conductors that have cross sectional area within the range of the rated AWG/kcmil conductors. For example a connector rated for 6 AWG – 250 kcmil may additionally be rated for 16 – 120 mm^2. See 6.1.4, 7.2.3, 25.22, and 25.23.

1.4 For connectors intended for use with stranded conductors, the following conductor strand configurations are intended:

a) Aluminum – Class B concentric, compressed, and unidirectional lay compact.

b) Copper – Class B concentric and compressed. Class C concentric, other stranding as indicated by marking.

c) Copper-Clad Aluminum – Class B concentric.

Other class and strand configurations may also be covered as indicated by marking.

1.5 These requirements also apply to uninsulated splicing connectors for use in general use circuits rated 2000 volts nominal or less and for use in specific applications rated 8000 volts nominal or less when the splicing connectors are installed according to the National Electrical Code.

1.6 These requirements cover splicing connectors intended for copper-to-copper or aluminum-to-aluminum conductor combinations, or both. Also covered are copper-to-aluminum or to copper-clad aluminum conductor combinations intended for intermixing of conductors and dry locations only.

1.7 These requirements do not cover:

a) Connectors intended for direct burial;

b) Insulated connectors intended for use at voltage levels in excess of 600 volts [1000 volts in a sign or lighting fixture (luminaire)];

c) Pressure terminal wire connectors;

d) Binding-screw terminals;

e) Built-in terminal connectors on devices rated under 30 amperes and intended for outlet-box mounting or having provision for strain relief; or

f) Built-in terminal connectors on devices having integral cable clamps.

1.8 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2A Undated References

2A.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

3 General

3.1 A connector intended for use with stranded conductor shall be constructed such that all strands of the conductor can be contained within the connector.

3.2 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) A pressure plate or plates and a screw or screws;

c) A special tool to form or crimp the connector barrel;

d) A plate of an insulation-piercing connector; and

e) A spring-action clamp connector.

Any rearrangement or adjustment of a connector that is necessary to adapt it to various sizes of conductor shall be obvious unless the connector is marked as described in 25.13.

3.2 revised October 10, 2001

3.3 There shall be no sharp edges or corners on the outer surface of a connector to result in damage to electrical insulation when contacted.

4 Materials

4.1 The main current-carrying part of a connector shall be of aluminum, an aluminum alloy, copper, a copper alloy, or equivalent material that is intended for the purpose.

4.2 The connector body of a copper, copper alloy, aluminum, or aluminum alloy connector intended for aluminum conductor shall be coated with an electrically conductive coating, such as tin, that will inhibit oxidation and corrosion. When the connector body is not coated with an electrically conductive coating, the connector shall either be shipped prefilled with an oxide-inhibiting compound, or be an aluminum-bodied connector intended for an aluminum conductor only.

4.2.3 The top cap of a lay-in lug or connector not in contact with the wire is not required to be plated.

4.3 A brass part of a connector shall be resistant to stress corrosion cracking. A brass part containing not more than 15 percent zinc is considered to be resistant to stress corrosion cracking.

4.4 A brass part, containing more than 15 percent zinc, shall comply with 10-Day Moist Ammonia-Air Stress Cracking Test, Section 23.

4.5 Iron or steel, when protected against corrosion by zinc, tin, or equivalent plating, may be used for screws, plates, yokes, springs, or other parts that are employed as a means of clamping the conductor – when such parts are not the primary current-carrying members.

4.6 Insulation used as a part of a connector shall be material intended for the marked temperature rating of the connector. The temperature limits of some of the commonly used insulating materials shall not exceed the values specified in Table 25.3.

4.7 The insulating material shall be a minimum flammability classification of V-2 or VTM2 as determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A material other than V-2 or VTM2 is able to be used when the wire connector complies with the requirements for the glow-wire test as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C at a temperature of 850°C (1,562°F).

4.7 revised October 10, 2001

4.8 Deleted October 10, 2001

4.9 Insulated twist-on or set-screw connectors rated for aluminum shall have insulation colored purple or brown. An insulated twist-on or set-screw connector rated for copper wire only shall not be colored purple or brown.

Effective date for 4.9 changed from September 28, 2000 to October 10, 2006

4.10 Porcelain or cold-molded composition used as insulation shall additionally comply with Moisture Absorption Test, Section 22.

PERFORMANCE

5 General

5.1 A splicing connector shall perform as intended when separate sets of samples are subjected to the tests specified in Table 5.1 and 5.2. As a result of the tests, there shall be no breakage of the conductor or any strand of a stranded conductor, stripping of threads, unintentional shearing of parts, separation of the conductor from the connector, or other unintentional damage to the connector. The insulation of an insulated connector shall not crack or break when the connector is assembled as intended on the conductor.

5.2 With reference to 5.1, separation of a conductor from a connector is to be determined by examination of the assembly after the Secureness Test, Section 11, and the Pullout Test, Section 13.

5.3 With reference to 5.1, breaking of the conductor or any strand of a stranded conductor is to be determined by examination of the complete connector assembly while still intact after the secureness and pullout tests. When the conductor or a strand of a stranded conductor becomes detached at the point where it enters the connector, breakage is determined to have occurred.

5.4 For a tool-applied crimp-on connector, when the conductors are secured by a single securing means, tests are to be conducted with the conductors pretwisted according to the instructions provided by the manufacturer and according to 25.14(d) and 25.20. The conductors are not required to be pretwisted when the design of the connector does not lend itself to direct contact, such as a butt-end splice.

5.5 At the manufacturer's option, tests of connectors intended for original equipment manufacturer (OEM) use will be conducted with the conductors not pretwisted. However, instructions for pretwisting the conductors shall be provided for field wiring applications. Instructions for pretwisting are optional for OEM wiring applications. When the connector can be crimped without providing direct contact between the conductors, then tests are to be conducted with the connector crimped so they are not in direct contact. Connectors tested with the conductors not pretwisted shall be marked as specified in 25.21.

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

5.7 A connector of copper or copper alloy is not required to be subjected to the heat-cycling sequence using copper conductors, unless the connector is dependent upon an insulation piercing, insulation-displacement, or spring-action type clamp.

5.8 A twist-on connector provided with a metal insert is not required to be subjected to the heat-cycling sequence using copper conductors.

5.9 With respect to 5.7 and 5.8, a pre-filled twist-on connector (with or without a spring insert) shall also be subjected to the heat cycling sequence using copper conductors. Prefilling usually consists of a gel, epoxy, or similar compound.

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5.10 The oven conditioning described in 18.2.2, 18.2.3, and Table 18.2 shall not cause the connector insulation to change so as to adversely affect the insulating properties of the conductor insulation and the wire connector. However, discoloration of the connector insulation is acceptable.

Table 5.1
Test sequences – all connectors

Section	Test sequences	Sample set
	Heat cycling sequence	
9	Heat cycling	4 connectors for each combination of conductors for which the connector is intended as required by 6.2.2 – 6.2.6.
	Static heating sequence	
10	Static heating	4 connectors for each combination of connector and test conductor or conductors required by 6.3.2.
11	Secureness	4 connectors for each combination of connector and test conductor or conductors required by 6.3.2.
12	Repeated static heating	Sample set previously subjected to the Static-Heating Test, Section 10, and the Secureness Test, Section 11.
13	Pull out	Sample set previously subjected to the repeated Static-Heating Test, Section 12.
	Mechanical sequence	
11	Secureness	2 connectors for each combination of conductors for which the connector is intended as required by 6.4.1 and 6.4.2.
13	Pull out	Sample set previously subjected to the Secureness Test, Section 11.
6.5	Max fill	For twist-on connectors only, 2 connectors for each combination of conductors for which the connector is intended as required by 6.5.1 and 6.5.2.
14	Over-torque	For connectors where the tightening torque is applied by means of a screwdriver only, 6 connectors. See Table 14.1.
	Spring-action clamp sequence	
15	Conditioning	6 connectors for each combination of conductors for which the connector is intended as required by 6.6.2.
16	Temperature	Sample set previously subjected to the Conditioning of Section 15.
17	Dielectric-voltage withstand	Sample set previously subjected to the Temperature Test, Section 16.
	Other	
23	10-day moist ammonia-air stress cracking test	3 connectors assembled to a 6 inch length of the maximum rated conductor and torqued to the value specified in 7.4.3.

Table 5.2
Additional tests – insulated connectors[a]

Section	Tests	Sample set
18	Dielectric voltage-withstand	For connectors employing thermosetting insulating material: 6 connectors in as-received condition. For connectors employing thermoplastic material: 6 connectors in as-received condition, 6 connectors assembled to conductors before oven conditioning, and 6 connectors assembled to conductors after oven conditioning.
19	Secureness of insulation	For connector insulation in the form other than a tubular sleeve and for use with 10 AWG or smaller conductors: 6 connectors. For connector insulation in the form of a tubular sleeve and for use with 10 AWG or smaller conductors: 6 connectors in as-received condition, 6 connectors after oven conditioning, 6 connectors assembled to conductors before oven conditioning, and 6 connectors assembled to conductors after oven conditioning.
21	Flexing	For connectors with insulating covers employing a hinge, latch, or lock: 6 connectors in as-received condition and assembled to conductors, 6 connectors assembled to conductors after oven conditioning, and 6 connectors assembled to conductors after ″cold″ conditioning.
22	Moisture-absorption	6 connectors
24	Installation at low-temperature	6 connectors

[a]Insulated connectors shall also be subjected to the test sequences described in Table 5.1.

6 Selection of Samples

6.1 General

6.1.1 Separate sample sets are to be used for each of the test sequences in Table 5.1 and 5.2.

6.1.2 Sample sets are to be tested using both solid and stranded conductors for Nos. 30 – 10 AWG (0.05 – 5.3 mm^2) sizes, and using stranded conductor for No. 8 AWG (8.4 mm^2) and larger sizes unless the connector is marked as specified in 25.10, in which case the conductor used is to be of the type or types marked on the connector.

6.1.3 Sample sets are to be subjected to the test sequences using the conductor material specified in Table 6.1 for the one or more conductor material combinations for which the connector is intended.

6.1.4 Testing using AWG/kcmil conductors are considered representative of Class 1 and 2 metric conductors (rigid solid and rigid stranded) within the cross sectional area envelope of the rated AWG/kcmil range. Class 5 and 6 metric conductors (flexible stranded) shall additionally comply with the requirements in 7.2.3.

6.2 Heat cycling

6.2.1 The basic sample set for the test is to consist of four connectors for each combination of connector and test conductor or conductors to be tested.

Table 6.1
Conductor material to be used in test sequences

Conductor for which connector is intended[a]	Conductor used in test sequences
1. Copper	Copper
2. Aluminum	Aluminum
3. Copper to copper[b]	Copper
4. Aluminum to aluminum[b]	Aluminum
5. Copper to aluminum[b], intermixed	Copper to aluminum

NOTES

1 Any conductor material may be used for the Dielectric Voltage-Withstand Test sequence.

2 When 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.

[a] Single conductor in an opening.

[b] Two or more conductors in an opening.

6.2.2 For a connector that is intended for splicing two conductors of the same size, samples sets are to be tested using the maximum size conductor – see 6.1.2 and 6.1.3.

6.2.3 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, heat-cycling tests are to 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.

6.2.4 For a connector that is intended for copper conductor in addition to aluminum, heat-cycling tests with copper conductor are not required to 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 conductor. With the concurrence of those concerned, the current used in the tests with aluminum conductor may be raised to the value normally used with copper conductor. See 5.7 and 5.8.

Example: A connector intended for copper conductor only has combinations marked as follows (see Table 9.1 for test currents):

a) One No. 10 AWG with one No. 10 AWG, with a test current of 56 amperes;

b) One No. 12 AWG with one No. 12 AWG, with a test current of 39 amperes;

c) One No. 14 AWG with one No. 14 AWG, with a test current of 33 amperes;

d) One No. 16 AWG with one No. 16 AWG, with a test current of 20 amperes;

e) One No. 10 AWG with three to seven No. 18 AWG, with a test current of 56 amperes; and

f) One No. 12 AWG with four to nine No. 18 AWG, with a test current of 39 amperes.

Samples selected for the heat-cycling test would be:

a) Two No. 10 AWG, with a test current of 56 amperes – see 6.2.2;

b) One No. 10 AWG with three No. 18 AWG, with a test current of 56 amperes – see above.

6.2.5 With reference to 6.1.3 and Table 6.1, when the connector is intended for the intermixing of conductors of different materials, the heat-cycling tests are to be conducted using the following conductor material. The test currents are based on the lesser current dictated by the two different conductor materials.

a) Maximum size copper with maximum size aluminum;

b) Maximum size copper with minimum size aluminum;

c) Minimum size copper with minimum size aluminum; and

d) Maximum size copper in combination with minimum size 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.

6.2.6 In addition to the tests in 6.2.5, 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 wireway, additional heat 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 obtain the specified wire combination. The test currents are to be based on the aluminum test current values specified in Table 9.1. 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).

6.3 Static-heating sequence

6.3.1 The sample set for the static-heating sequence is to consist of four connectors for each combination of connector and conductor or conductors to be tested.

6.3.2 For the static-heating sequence – see Table 5.1 – the same selection of sample sets as indicated in 6.2.2 – 6.2.6 is to be tested.

6.4 Mechanical sequence

6.4.1 For a connector that is 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, two samples of each of the combinations of conductors for which the connector is intended, as indicated in (a) – (i), are to be subjected to the secureness and pullout tests. See Section 11, Secureness Test, and Section 13, Pullout Test. Other combinations are to be tested when it appears that such tests are necessary.

a) Smallest total circular-mil area;

b) Largest total circular-mil area;

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

g) Smallest number of largest conductors;

h) Two conductors of the minimum size conductor shall be the same AWG size; and

i) A single maximum with a single minimum.

6.4.2 When a combination of conductors selected according to any one of the items in 6.4.1 is the same – with respect to the total number of conductors and the number of conductors of the same size – as a combination indicated by one or more of the other items in 6.4.1 or 6.3.2, the test is to be conducted on only one set of samples.

6.5 Maximum fill

6.5.1 In addition, a twist-on connector shall be tested with the following combinations:

a) The conductor combination having the maximum fill as specified in 6.5.2; and

b) The largest total number of conductors (any combination of sizes).

Two samples of each of the combinations shall be subjected to the Secureness Test, Section 11, and the Pullout Test, Section 13. The conductor insulation type shall be in accordance with 7.2.7.

6.5.2 The maximum fill of a conductor combination is calculated by adding the areas for each of the conductors in the combination as indicated in Table 6.2.

Table 6.2
Overall area for conductor and type THW insulation

Conductor size		Overall area conductor and insulation	
AWG	(mm^2)	$inch^2 \times 10^{-3}$	(mm^2)
30	(0.05)	2	(1.29)
28	(0.08)	2.5	(1.61)
26	(0.13)	3	(1.94)
24	(0.20)	3.5	(2.25)
22	(0.32)	4	(3.08)
20	(0.52)	6	(4.01)
18	(0.82)	8	(5.69)
16	(1.3)	10	(7.06)
14	(2.1)	20	(13.46)
12	(3.3)	26	(16.78)
10	(5.3)	33	(21.50)
8	(8.4)	55	(35.84)
6	(13.3)	72	(46.81)
4	(21.2)	97	(62.76)

6.6 Spring-action sequence

6.6.1 The sample set for the spring-action sequence is to consist of six connectors for each combination of connector and conductor or conductors to be tested.

6.6.2 For the spring-action sequence – see Table 5.1 – the connector and the combinations of conductors for which the connector is intended, as indicated in (a) and (b), are to be subjected to conditioning, and the temperature and dielectric voltage-withstand tests according to Sections 15 – 17. Other combinations shall not be tested unless it appears that such tests are necessary.

a) The maximum size conductor; and

b) When a range of conductor sizes is to be accommodated, the minimum size conductor.

See 6.1.2 and 6.1.3.

6.7 Over torque

6.7.1 When the tightening torque of a connector is applied by means of a blade-type screwdriver, six samples are to be subjected to the Over-Torque Test, Section 14.

6.8 All other tests

6.8.1 The number of samples required for the Dielectric Voltage-Withstand, Secureness of Insulation, and Flexing Tests are specified in Sections 18, 19, and 21, respectively.

7 Preparation of Samples

7.1 General

7.1.1 Representative samples of the connector are to be connected to conductors of the proper type, length, and size as specified in the instructions furnished with the connector by the manufacturer. For the heat-cycling test, control-conductor assemblies are also to be prepared, wired in series with the sample sets used for the heat-cycling test and carrying the same test current. See 7.2.2 – 7.2.7, 7.5.1, 7.5.2, and 8.4.

7.1.2 When a connector is to be assembled to conductors by means of a specific tool, this tool is to be used in the intended manner.

7.1.3 A connector that may be assembled to a conductor by more than one type of specific tool, shall perform acceptably in the test when any of the specified tools are used. In selecting tools for assembly of a connector to a conductor, the following features are to be considered:

a) Profile, width, and depth of a connector;

b) Material of connector body;

c) Crimping die geometry;

d) The number of crimps; and

e) Similarity of crimp forces.

7.1.4 Except as noted in 5.4, when specific instructions for connecting the connector to the conductor are furnished with the connector by the manufacturer, such instructions are to be followed in the preparation of the samples except that the conductor is not to be brushed or abraded and an antioxidant is to be used only when the connector is prefilled with the antioxidant. See 25.14(d).

7.2 Test and control conductors

7.2.1 All test sample and control sample conductors are to be new (previously unused) and comply with the requirements in Table 7.2. See 6.1.2 and 7.2.2. Conductors may be previously used:

a) With the concurrence of all parties concerned; and

b) When the conductors have not attained a temperature of over 120°C (248°F) in previous tests.

Used conductor ends shall be cut off and the resulting new ends of the conductor re-stripped in accordance with 7.3.1 – 7.3.5.

7.2.2 A connector may be acceptable for a copper conductor other than Class B or Class C stranding when the connector is subjected to all test sequences using the other stranding. See 25.11.

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

7.2.4 Other than noted in 7.2.7, the insulation for copper conductors is to be black, Type RW90, T90 Nylon, THHN, THW, USE, or XHHW for No. 14 AWG (2.1 mm^2) and larger. Numbers 22 – 16 AWG (0.32 – 1.3 mm^2) conductors are to be insulated with black thermoplastic insulation at least 0.030 inch (0.76 mm) thick. Numbers 30 – 24 AWG (0.05 – 0.20 mm^2) conductors are to be insulated with black thermoplastic insulation at least 0.010 in. (0.25 mm) thick. In each of the above cases, insulation colored other than black shall be used only when agreeable to those concerned.

7.2.5 Other than noted in 7.2.7, the insulation for aluminum conductors is to be black, Type USE for all stranded sizes and Type RW90, T90 Nylon, THHN, THW, USE, or XHHW for solid No. 12 – 10 AWG (3.3 – 5.3 mm^2) conductors. Insulation colored other than black is to be used only when agreeable to those concerned.

7.2.6 A separator is to be located between the conductor and the insulation of a stranded conductor unless examination of the conductor shows that the insulation has not penetrated beyond the first strand layer during the manufacturing process.

7.2.7 With reference to 6.5.1 and 18.1.4, the insulation shall be black and have a nominal thickness as stated in Table 7.1.

Exception No. 1: Insulation colored other than black may be used if agreeable to those concerned.

Exception No. 2: If agreeable to those concerned, other conductor thicknesses (types) are allowed when the connector is additionally marked in accordance with 25.8.

Revised 7.2.7 effective October 10, 2006

Table 7.1
Conductor insulation thickness for maximum fill

Conductor size, AWG (mm^2)	Nominal insulation thickness, in. (mm)
30 – 24 (0.05 – 0.20)	0.010 (0.25)
22 – 16 (0.32 – 1.3)	0.030 (0.76)
14 – 10 (2.1 – 5.3)	0.045 (1.14)
8 – 6 (8.4 – 13.3)	0.060 (1.5)

7.2.8 Deleted October 10, 2001

7.2.9 The test and the control conductors are to be as follows. See also 7.2.4 – 7.2.7 and Table 7.2.

a) Aluminum:

1) Solid – No. 12 AWG (3.3 mm^2) and larger, complying with the requirements for aluminum wire stock intended as an electrical conductor.

2) Stranded – Nos. 12 – 6 AWG (3.3 – 13.3 mm^2), reverse lay concentric or compressed Class B stranding, aluminum designation 1350-H19 (ASTM B230) or 1350-H16 or 1350-H26 (ASTM B609), and having an iron content of 0.4 percent maximum.

b) Copper:

1) Solid and Stranded – Nos. 30 – 16 AWG (0.05 – 1.3 mm^2) soft annealed, tinned or untinned.

2) Solid – No. 14 AWG (2.1 mm^2) and larger, soft annealed, and untinned.

3) Stranded – Nos. 14 – 10 AWG (2.1 – 5.3 mm^2) soft annealed, and untinned. The stranding is to be concentric or compressed Class B or concentric Class C. See 7.2.2.

4) Stranded – Nos. 8 – 6 AWG (8.4 mm^2 – 13.3 mm^2). The stranding is to be compact Class B. See footnote b of Table 7.2.

Revised 7.2.9 effective October 10, 2006

Table 7.2
Conductor for test

Effective date for Table 7.2 changed from September 28, 2000 to October 10, 2006

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

[a] Number of strands may vary.
[b] Sizes No. 6 and No. 8 AWG copper shall be compact stranding.

7.2.10 The length of the test conductor measured from the conductor entry face of the test connector to the equalizer for the heat-cycling test or to the face of the connector at the other end of the test conductor for the static-heating test shall be as specified in Table 7.3.

Table 7.3
Test conductor length

Conductor size		Minimum conductor length[a]	
AWG	(mm^2)	Inches	(mm)
30 – 8	(0.05 – 8.4)	8	(203)
6	(13.3)	12	(305)

[a] The conductor length for the secureness test in the static-heating sequence is not to be less than that specified in 11.4.

7.2.11 For the heat-cycling tests, the control conductor is to be:

a) Approximately twice the length of the test conductors used with the connector samples; and

b) The same size and material as the conductor used to select the test current.

7.3 Conductor stripping

7.3.1 Insulated conductors, excluding those intended for use with insulation piercing connectors, are to be stripped immediately prior to insertion into the connector (see 7.3.2 – 7.3.4) and are to be assembled in the connector in the intended manner. The insulation is to be stripped off the conductor so as to provide a clean abrupt end (not pencilled). Care is to be taken in stripping conductors to avoid cutting, nicking, scraping, or otherwise damaging the conductors. Care is also to be exercised in removing all foreign materials, such as insulation, separators, and the like, from the stripped ends. However, the conductor is not to be brushed or abraded.

7.3.2 For an insulated or uninsulated connector marked with a nominal strip length as specified in 25.14(c) and Table 25.2, the static-heating sequence, mechanical-sequence, spring-action sequence, and the heat-cycling sequence tests are to be conducted with conductors stripped to the minimum tolerance specified in Table 7.4. The dielectric voltage-withstand test, on an insulated connector, is to be conducted with conductors stripped to the marked nominal strip length.

7.3.3 For an insulated connector marked with a maximum conductor strip length and a minimum conductor strip length according to 25.14(c) and Table 25.2, the static-heating sequence, mechanical-sequence, spring-action sequence, and the heat-cycling sequence tests are to be conducted with conductors stripped to the minimum length specified by the manufacturers, and the dielectric voltage-withstand test is to be conducted with conductors stripped to the maximum length specified by the manufacturer.

7.3.4 For an uninsulated connector marked with a minimum conductor strip length, the static-heating-sequence, mechanical-sequence, spring-action sequence, and the heat-cycling sequence tests are to be conducted with conductors stripped to the minimum length.

Table 7.4
Strip-length tolerances for conductors

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

7.3.5 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 is to be stripped to allow the conductor to make contact with the full available length of the connector that contains the securing means. The conductor is to be positioned so that 1/4 – 1/2 inch (6.4 – 12.7 mm) of bare conductor is exposed between the conductor-entry face of the connector and the beginning of the insulation. When the conductor can project through the wire connector without interference, the conductor is to be installed to project not more than 1/4 inch (6.4 mm).

7.4 Tightening torque

7.4.1 The conductor and the connector are to be connected before the start of any test. No additional tightening is to be done during the testing program.

7.4.2 The specified torque is to be applied until the specified value of torque is maintained, with a static torque reading, for 5 seconds.

7.4.3 All connectors intended for use with screwdriver type slotted heads are to be tightened to the torque values specified in Table 7.5. Tightening torque values for split bolt splicing connectors are specified in Table 7.6. Samples prepared for the heat-cycling test are to be tightened using the values of torque shown in Column A of the tables. Samples prepared for the static-heating-sequence, mechanical-sequence, and dielectric voltage-withstand tests are to be tightened using the values of torque shown in Column B of the tables.

Table 7.5
Tightening torque for screws

Size or diameter of screw	Torque, pound-inch (N·m)			
	A		B	
No. 10 (4.8 mm diameter) and smaller	4.8	(0.55)	6	(0.68)
1/4 inch (6.4)	6.4	(0.72)	8	(0.91)
5/16 inch (7.9 mm) and larger	8.8	(0.99)	11	(1.24)

Table 7.6
Tightening torque for split-bolt connectors hexagonal head external drive socket wrench

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

7.4.4 For a twist-on connector, the tightening torque to be used in the static-heating, mechanical-sequence, and dielectric voltage-withstand tests is the lesser of:

a) One-half pound-inch (0.056 N·m) per 1000 circular mil (0.111 N·m/mm^2) area for the total circular mil (mm^2) area of copper conductors in the combination under test plus 0.3 pound-inch (0.034 N·m) per 1000 circular mil (0.066 N·m/mm^2) area for the total circular mil (mm^2) area of aluminum conductors in the combination under test; or

b) Twelve and one-half pound-inch per inch (0.056 N·m/mm) of gripping diameter.

7.4.5 For a hand-applied, twist-on connector, the tightening torque to be used in the heat-cycling test is to be 80 percent of the value specified in 7.4.4.

7.4.6 There is no specified torque for a spring-action connector. The conductor is to be stripped to the appropriate length and pushed into the connector according to the manufacturers instructions. See also 25.14.

7.5 Equalizer

7.5.1 For the heat-cycling test, the free end of each stranded control conductor and each stranded conductor that has been terminated or is intended to be terminated in a test connector is to be welded or brazed to an equalizer to make a thorough electrical connection for each strand. An equalizer is not required but may be used for a solid test conductor. For other than control conductors, tool-applied compression connectors without welding shall be used only when acceptable to the manufacturer. With the concurrence of those concerned, the equalizer is not required to be used when the cables are welded to each other.

7.5.2 An equalizer is to be constructed using:

a) A short length of copper or aluminum bus having one or more chamfered 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.

The end of the conductor that projects through the bus – chamfer out – or the pressure screw-type connector is to be welded into a homogeneous mass with the bus or connector. When those concerned are in concurrence, then the free end of the conductor projecting out of the pressure screw-type connector is not required to be welded. A wire connector is not to be larger than that needed for the conductor size involved and an equalizer bus is not to be larger than the bus sizes tabulated in Table 7.7. 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 suitable for 90°C and marked as specified in 25.17.

Table 7.7
Equalizer dimensions

Range of test current, amperes	Maximum cross-section, inches (mm)			
	Copper		Aluminum	
50 or Less	1/8 x 1/2	(3.2 x 12.7)	1/8 x 1/2	(3.2 x 12.7)
51 – 125	1/8 x 1	(3.2 x 25.4)	1/8 x 1-1/4	(3.2 x 31.8)

7.5.3 With reference to 7.5.2(a), the length of the bus bar is not to exceed the width.

7.5.4 Equalizers are not to be used on samples intended for the static-heating sequence test as it is necessary to insert the open end of the conductor through a bushing for the secureness test.

8 Temperature Measurements

8.1 Temperatures are to be measured by thermocouples consisting of conductors not larger than No. 24 AWG (0.21 mm^2) and not smaller than No. 30 AWG (0.005 mm^2).

8.2 When thermocouples are used to determine temperatures in electrical equipment, it is common practice to employ thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan conductor and a potentiometer-type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. Thermocouples smaller than No. 30 AWG are not prohibited from being used when making referee temperature measurements.

8.3 The thermocouples and related instruments are to be accurate and calibrated according to good laboratory practice. The thermocouple conductor is to conform with the requirements as listed in the Initial Calibration Tolerances for Thermocouples table in Temperature-Measurement Thermocouples, ANSI/ISA MC96.1-1982.

8.4 A thermocouple on a control conductor used in the heat-cycling test is to be located at the midpoint of the conductor and under the conductor insulation. The thermocouple is to be secured by solder, an adhesive, or by other equivalent means that does not interfere with the replacement of the conductor insulation over the thermocouple location and that does not require penetration of the surface of the conductor metal; for example, drilling and peening is not acceptable.

8.5 For temperature measurements on a copper control conductor, the following technique is to be employed:

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

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

c) The flap of insulation is to be repositioned and secured by a tightly wrapped, double layer of black thermoplastic tape 0.007 inch (0.18 mm) thick extending not more than 1/2 inch (12.7 mm) on each side of the flap, or by another acceptable means of holding the test conductor insulation in place.

8.6 For temperature measurements on an aluminum control conductor, the following technique is to be employed:

a) A 1-inch (25.4-mm) minimum length of insulation over the full circumference of the conductor is to be removed.

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

c) For a stranded conductor, one strand is to be pried out just enough to insert the end of a soft copper ribbon – 1/4 inch (6.4 mm) wide by 0.005 inch (0.13 mm) thick – to a length that overlaps 1/8 inch (3.2 mm) as illustrated in Figure 8.1. The strand of the conductor is then lightly tapped back down on the copper ribbon. The copper ribbon is to be wrapped partially around the conductor strands back to the one strand that has been pried out. The thermocouple is to be located on the copper ribbon in the valley formed by the pried-out strand and the adjacent strand and is to be soldered in place. The copper ribbon is to be wrapped completely

around the bundle of strands and is to be cut off so that a 1/8 inch overlap results. The ribbon is to be secured in place by reheating the solder behind the ribbon where the thermocouple is located.

d) The section of insulation removed as described in (a) is to be attached with the slit side directly opposite the thermocouple junction. Thin-walled heat-shrinkable 125°C (257°F) tubing or a tightly wrapped, double layer of black thermoplastic tape extending not more than 1/2 inch (12.7 mm) on each end of the section of insulation is to be used to hold it in place.

e) The technique described in 8.5, which applies to copper conductors, shall be used with aluminum conductors when the thermocouple is secured by an adhesive.

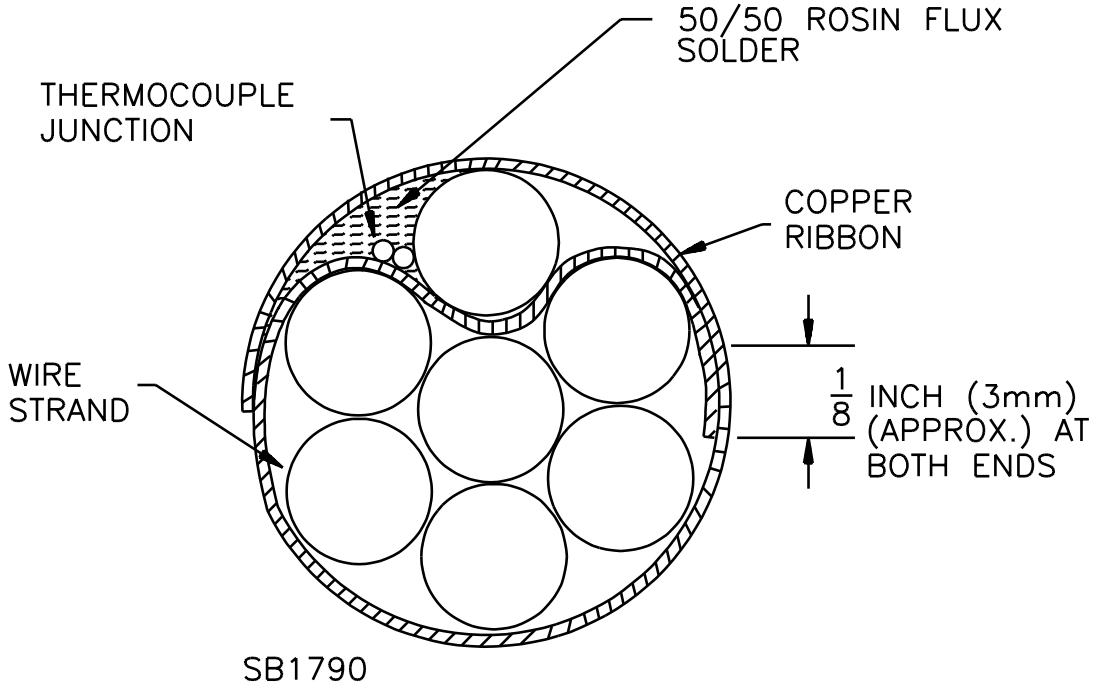
8.7 A thermocouple on a wire connector is to be positioned to sense the highest temperatures generated by the connector. In general, the thermocouple sensing bead is to be located on one of the conductor entry sides of the connector and closest to the conductor/connector contact surface. A thermocouple is to 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; for example, by peening the thermocouple into a small hole drilled in the connector or by the use of small quantities of a thermally conductive adhesive.

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

a) The thermocouple is to be attached to the maximum size conductor – as described in 8.5 or 8.6 – not more than 1/2 inch (12.7 mm) from the edge of the connector; or

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

Figure 8.1
Method for attaching thermocouples to stranded aluminum control conductors used for heat cycling test



8.9 Thermocouples to measure the ambient temperature for a connector sample set under test are to be installed on 2 inch (50.8 mm) square by 1/4 inch (6.4 mm) thick sections of unplated copper bus. For vertically mounted connectors, one bus is to be located 2 feet (610 mm) in front and one bus 2 feet in back of the sample set and control conductor; when several sample sets of connectors are included, bus sections are to be located 2 feet in front, 2 feet in back, and 2 feet on each side of the test assembly. For horizontally mounted connectors in an assembly of one or more sample sets of connectors, bus sections are to be located 2 feet in front, 2 feet in back, and 2 feet on each side of the test assembly. For test assemblies employing an insulating backboard as mentioned in 9.2.4, no bus section is to be mounted behind the test assembly. All buses are to be mounted in a vertical plane at the same elevation as the wire connectors being tested. All measurements are to be made to the centerline of the nearest connector or conductor. When all thermocouples employed are the same length, they are to be connected in parallel to provide an average ambient temperature.

8.10 An alternate method of locating the thermocouple for a horizontal test assembly is to place one bus at the center of a loop formed by the sample sets and control conductors.

8.11 A test sample is considered to have attained a stable temperature during the static-heating test – see 10.3 – or during the off period of the heat-cycling test – see 9.1.3 – when three readings taken at not less than 10-minute intervals show no more than a 2°C (3.6°F) variation between any two of the readings. The time to temperature stabilization as mentioned in 9.1.5 is the current-off time at which the first of the three readings indicating stable temperature was recorded.

9 Heat-Cycling Test

9.1 General

9.1.1 The temperature rise of a connector shall not exceed 125°C (225°F) above the ambient temperature for any recorded cycle when subjected to the tests described in 9.1.2 – 9.2.6. The stability factor "S_i" (see 9.1.4) determined for each temperature measurement shall not exceed ±10.

9.1.2 Samples are to be selected and prepared as described in Section 6, Selection of Samples, and Section 7, Preparation of Samples. Connectors intended for use with snap-on molded insulating covers or packaged with insulating materials that are intended to be wrapped around the complete connector/conductor termination are to be tested without the insulating covers or material installed. The sample sets are to complete 500 continuous cycles of current-on and current-off operations, while carrying the applicable current specified for the connector temperature rating and conductor size being tested specified in Table 9.1. Temperatures are to be measured and recorded for at least 1 cycle of each working day. Temperature measurements are to be made at 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles.

9.1.3 Each cycle of operation is to consist of 1 hour on and 1 hour off. The current-off time is to be reduced after the first 25 cycles of testing to 5 minutes more than the maximum time it takes any connector to reach a stable temperature during the current-off period. Forced-air cooling is to be employed to reduce the current-off time with the concurrence of those concerned. See 8.11.

9.1.4 The stability factor "S_i" for each of the 11 temperature measurements mentioned in 9.1.2 is determined by applying the following equations:

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

$$S_i = d_i - D$$

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.

The value for d_i is to be determined by subtracting the associated control-conductor temperature from the terminal temperature. The value for d_i is a positive number when the terminal temperature is more than that of the control-conductor and a negative number when the terminal temperature is less than that of the control-conductor. The average of the 11 temperature deviations is then to be determined.

Example:

Temperature in °C

Cycle number	Connector	Control conductor	Temperature deviation, d	Stability factor, S
25	130	135	-5	-6.5
50	131	136	-5	-6.5
75	133	135	-2	-3.5
100	136	135	1	-0.5
125	136	135	1	-0.5
175	138	135	3	1.5
225	139	136	3	1.5
275	138	135	3	1.5
350	141	136	5	3.5
425	142	136	6	4.5
500	142	136	6	4.5
			Sum = 16 D = +1.5	

9.1.5 Temperatures are to be measured within the last 5 minutes of the normal current-on time. When the number of samples or the speed of the data acquisition system is such that not all measurements can be completed within 5 minutes, the current-on time is to be extended as necessary to complete such measurements.

9.2 Sample test assembly

9.2.1 Sample sets and the control conductor are to be connected in series and to a current source that is maintained at or above the required value by regulation or frequent adjustment.

Table 9.1
Test current for copper and aluminum conductors, amperes

Effective date for Table 9.1 changed from September 28, 2000 to October 10, 2006

Conductor size		Copper		Aluminum	
AWG	(mm^2)	Static heating[a]	Heat cycling	Static heating[a]	Heat cycling
30	(0.05)	3.0	3.5	–	–
28	(0.08)	3.5	4	–	–
26	(0.13)	5.5	6	–	–
24	(0.20)	7	8	–	–
22	(0.32)	9	12	–	–
20	(0.52)	12	16	–	–
18	(0.82)	17	19	–	–
16	(1.3)	18	20	–	–
14	(2.1)	30	33	–	–
12	(3.3)	35	39	30	43
10	(5.3)	50	56	40	56
8	(8.4)	70	80	55	77
6	(13.3)	95	105	75	109

NOTE – Values are for 75°C single conductor in free air ampacities, National Electrical Code, ANSI/NFPA 70-1999.
[a] See 9.1.2 and 9.1.3.

9.2.2 When bus-bar lengths are needed to connect the equalizers, the lengths are to be the minimum required to provide sufficient contact area for the equalizers while maintaining the center-to-center sample spacings specified in 9.2.3. The cross-section dimensions of the bar are to be sufficient to prevent a test-current density in excess of 1000 amperes per square inch (155 A/cm^2) for copper or 800 amperes per square inch (124 A/cm^2) for aluminum bus.

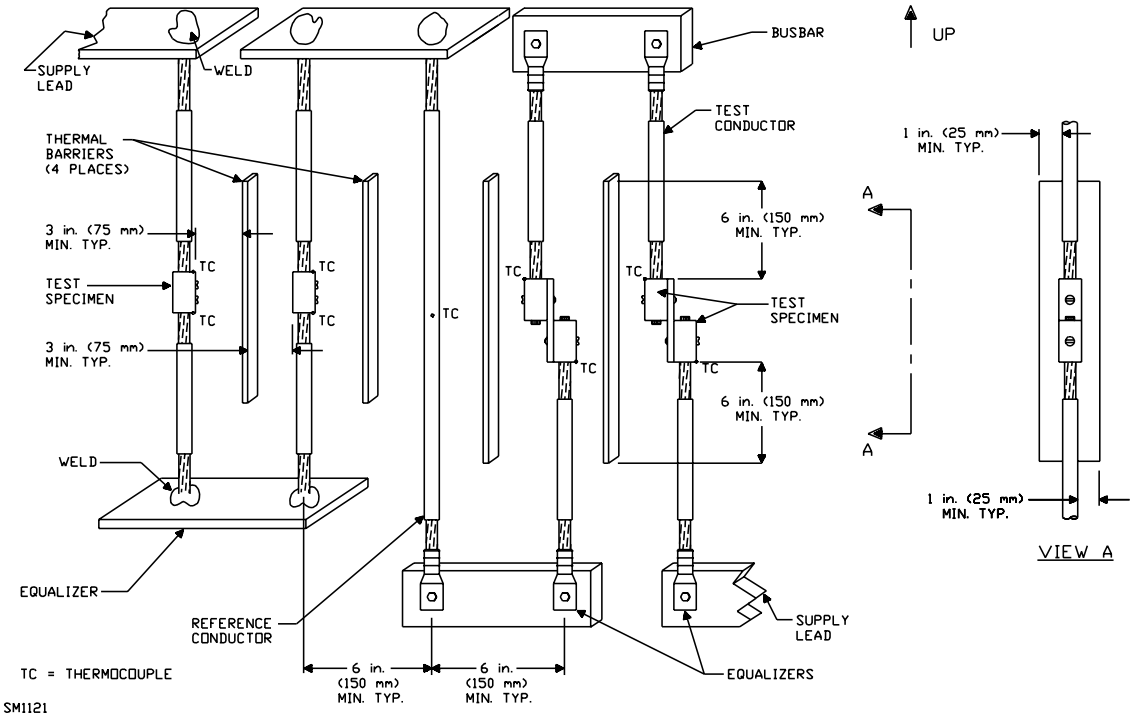
9.2.3 Individual connector/conductor samples are to be separated by at least 18 inches (457 mm) when measured center-to-center. The spacing shall only be reduced, either with the concurrence of those concerned, or when a thermal barrier is used between assemblies. When a thermal barrier is used between assemblies, the spacing shall not be less than 6 inches (152 mm). The thermal barrier is required to extend at least 6 inches (152 mm) in a vertical direction and 1 inch (25.4 mm) in a horizontal direction beyond the extremities of the connector.

9.2.4 The temperature measurement location for the control conductor and connector samples is to be located at least 24 inches (610 mm) from the building floor, ceiling, and walls. The spacing is not required to be maintained when a solid, thermal insulating backboard separates the test samples from the building floor, ceiling, or walls. Samples are to be spaced at least 4 inches (102 mm) from the insulating backboard.

9.2.5 Test assemblies and the control conductor are to be suspended vertically or horizontally in free air by the use of loose-fitting, nonmetallic tie straps around the conductors or by suspension from the equalizers supported in turn by nonmetallic blocks. The method used is to prevent the test connections from being disturbed during handling of the samples and to minimize the transmission of tensile loads to the test connectors through test or supply conductors. See Figure 9.1 for an example of a vertical arrangement.

9.2.6 Test assemblies are to be located in a substantially vibration and draft-free location where the average ambient air temperature can be maintained in the range of 15 – 35°C (59 – 95°F). The ambient temperature is to be kept within ±4°C (±7.2°F) at all times during the test unless a greater variation in temperature is agreeable to those concerned.

Figure 9.1
Vertical arrangement of sample for heat-cycling test



10 Static-Heating Test

10.1 Samples are to be selected and prepared as described in Section 6, Selection of Samples, and Section 7, Preparation of Samples, except that equalizers are not to be used. See 7.5.4.

10.2 The test assembly is to be as described for the heat-cycling test in 9.2.1 – 9.2.6.

10.3 The sample sets are to carry continuously the value of test current specified in Table 9.1 for the conductor size tested until stable temperatures are reached – see 8.11. The temperature rise above ambient temperature shall not exceed 50°C (90°F).

11 Secureness Test

11.1 The joint between a connector and the conductor of a sample set required for the static-heating sequence tests and a sample set required for the mechanical sequence tests shall be intact after being subjected to the test described in 11.2 – 11.4 for 30 minutes.

11.2 Except as noted in 11.4 and 11.5, the setup is to be as shown in Figure 11.1. A connector is to be fastened to a length of conductor that is at least 3 inches (76 mm) longer than the height specified in Table 11.1. As shown in Figure 11.1, the free end of the conductor is to be passed through a bushing of the size specified in Table 11.1. The bushing is to be attached to an arm driven by a motor in such a manner that the center of the bushing describes a circle in a horizontal plane. The circle is to have a diameter of 3 inches, and its center is to 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 is to be within 1/2 inch (12.7 mm) of the distance specified in the column titled Height in Table 11.1. The bushing is to be lubricated to prevent binding, twisting, or rotation of the insulated conductor. A weight as specified in Table 11.1 is to be suspended from the free end of the conductor. The testing machine is to be operated at the rate of 9 revolutions per minute.

11.3 When the connector is secured to conductors of different sizes, the weight is to be attached to the smallest conductor and the entire assembly of connector, conductors, and weight is to be suspended by means of the largest conductor. The values of the weight, W, and the height, H, are to be the applicable value indicated in Table 11.1 for the size of the conductor to which the weight is attached. Terminal connectors or other means that will distribute the stress uniformly among the strands of the conductor are to be used for attaching the weight and for securing the assembly to the frame of the testing machine. 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 weight are to be allowed to project not more than 1/4 inch (6.4 mm) beyond the body of the connector; except that these ends of the conductors are to be cut off flush with the body of the connector when the instructions for the use of the connector so indicate.

11.4 A splicing connector for making tap connections at a right angle to the through conductor is to be connected to a length of through conductor and a length of tap conductor, each of the size for which the connector is intended. The assembly is to be supported by a U-shaped yoke, the arms of which grasp the through conductor on each side of the connector approximately 2 inches (51 mm) from the ends of the connector. The depth of the yoke is to be approximately 3 inches (76 mm). The yoke is to be secured firmly to the frame of the testing machine so that the tap conductor hangs vertically. The weight, which is to be suspended from the free end of the tap conductor after it has passed through the bushing of the testing machine, is to be as specified in Table 11.1 according to the size of the tap conductor. The length of the tap conductor is to be at least 3 inches more than the height specified in Table 11.1, corresponding to the size of the tap conductor. The testing machine is to be operated as described in 11.3.

11.5 The setup for a spring-action connector is to be as shown in Figure 11.1 except the connector under test is to be rigidly secured in a vertical position on the frame of the testing machine. The bushing diameter, height, and weight are to be based on Table 11.1.

Figure 11.1
Splicing-connector test arrangement

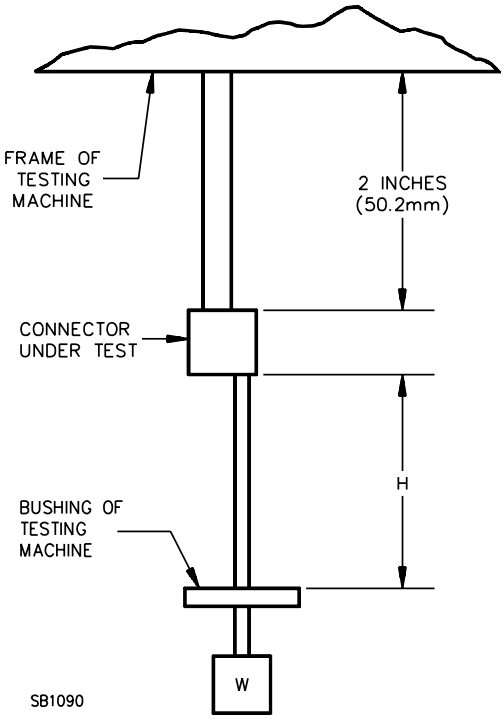


Table 11.1
Test values

Effective date for Table 11.1 changed from September 28, 2000 to October 10, 2006

Size of conductor		Diameter of bushing hole[a]		Height[b]		Weight, pounds (kg)			
AWG	(mm^2)	Inches	(mm)	Inches	(mm)	Copper		Aluminum	
18	(0.82)	1/4	(6.4)	10-1/4	(260)	2	(0.9)	–	
16	(1.3)	1/4	(6.4)	10-1/4	(260)	2	(0.9)	–	
14	(2.1)	3/8	(9.5)	11	(279)	3	(1.4)	–	
12	(3.3)	3/8	(9.5)	11	(279)	5	(2.3)	1.5	(0.7)
10	(5.3)	3/8	(9.5)	11	(279)	5	(2.3)	1.5	(0.7)
8	(8.4)	3/8	(9.5)	11	(279)	8	(3.6)	3	(1.4)
6	(13.3)	1/2	(12.7)	11-3/4	(298)	18	(8.2)	9	(4.1)

[a] When a hole with the diameter given is not adequate to accommodate the conductor without binding, a bushing having a hole of slightly larger diameter is not prohibited from being used.

[b] For Nos. 12 – 6 AWG aluminum conductor, use 12-1/2 inches (318 mm).

12 Repeated Static-Heating Test

12.1 The sample sets previously subjected to the static-heating test and the secureness test are to be subjected to a repeated static-heating test as described in Static-Heating Test, Section 10. Acceptance criteria shall be as described in Section 10.

13 Pullout Test

13.1 A connector that is required to be tested for pullout as indicated in Table 5.1 shall not become separated from any conductor attached to it as a result of being subjected to the pullout test described in 13.2 and 13.3.

13.2 For an insulated connector in which the insulation is attached to the connector during installation, the test is to be conducted with the insulation in place when it is always supplied with the connector by the manufacturer. Otherwise the test is to be conducted without the insulation. Breakage or tearing of the insulation of an insulated connector is acceptable in the pullout test. The pull is to be exerted by means of a tension-testing machine or the equivalent so that there is no sudden application of force or jerking during the test. Deadweights are not prohibited from being used as an equivalent force.

13.3 The connector is to be suspended from the largest conductor that it accommodates. Beginning with the smallest conductor, one conductor of each size of conductors in the combination shall be separately subjected for 1 minute to the force specified in Table 13.1. With the concurrence of those concerned, the pullout test on different sizes of conductors shall be conducted on separate samples that have also been subjected to the secureness test. Two samples for each wire size are to be tested.

Table 13.1
Test values for pullout test

Size of conductor		Pullout force	
AWG	(mm^2)	pounds	(N)
30	(0.05)	1-1/2	(6.9)
28	(0.08)	2	(8.9)
26	(0.13)	3	(13.4)
24	(0.20)	5	(22.3)
22	(0.32)	8	(35)
20	(0.52)	10	(44)
18	(0.82)	10	(44)
16	(1.3)	15	(66)
14	(2.1)	25	(111)
12	(3.3)	35	(155)
10	(5.3)	40	(178)
8	(8.4)	45	(200)
6	(13.3)	50	(222)

14 Over-Torque Test

14.1 A connector where the torque is applied by means of a blade-type screwdriver shall be capable of withstanding the values of torque specified in Table 14.1. There shall be no shearing of parts, stripping of threads, or other damage to the connector. The insulation of an insulated connector shall not crack or break.

Table 14.1
Over-torque test values

Size or diameter of screw,(mm)	Torque, pound-inch (N·m)	
No. 10 (4.8 and smaller)	9	(1.02)
1/4 inch (6.4)	20	(2.26)
5/16 inch (7.9 and larger)	30	(3.39)

14.2 Six samples of the connector are to be subjected to the test.

14.3 A hardened steel rod is to be fully inserted into the connector. The diameter of the rod is to be one-half the conductor opening of the connector, as measured perpendicular to the axis of the screw.

14.4 When the connector uses a headless screw, the width of the screwdriver blade is to be at least 90 percent – but not more than 100 percent – of the minor diameter of the screw. When the connector uses a headed screw, the width of the blade is to be not less than the diameter of the head. Torque is to be applied for 5 seconds.

15 Conditioning

15.1 A spring-action clamp-type connector shall be subjected to the conditioning specified in 15.3. Upon completion of this conditioning, the connector shall be subjected to the Temperature Test, Section 16, and the Dielectric Voltage-Withstand Test for Spring-Action Connections, Section 17.

15.2 Samples are to be selected and prepared as described in Section 6, Selection of Samples, and Section 7, Preparation of Samples.

15.3 The connectors are to be subjected to conditioning consisting of nine insertion and withdrawals of a conductor of the same size and type to be used for Temperature Test, Section 16, and the Dielectric Voltage-Withstand Test for Spring-Action Connections, Section 17. A tenth insertion of a newly-stripped, previously unused length of conductor is to be made and left in place for the Temperature Test, Section 16, and the Dielectric Voltage-Withstand Test for Spring-Action Connections, Section 17.

16 Temperature Test

16.1 A spring-action connector shall be capable of functioning without the temperature rise exceeding 50°C (90°F) above the ambient temperature. Upon completion of this test, the connector shall be subjected to the Dielectric Voltage-Withstand Test for Spring-Action Connections, Section 17.

16.2 The samples conditioned according to Conditioning, Section 15, are to be subjected to this test, using an ambient temperature of 25°C (77°F).

16.3 The samples are to be connected in series and a current is to be passed through the circuit. The values of current used for this test are to be the applicable values specified in the static-heating columns of Table 9.1 for the conductor size and type. The test is to be run for 30 days without interruption. Temperatures are to be measured and recorded every 24 hours.

17 Dielectric Voltage-Withstand Test for Spring-Action Connections

17.1 A spring-action connector shall withstand without breakdown for 1 minute the application of a 60-hertz essentially sinusoidal potential of 1000 volts plus twice the rated voltage of the connector between:

a) Live parts that are not conductively interconnected; and

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

17.2 The samples that have been previously subjected to the Temperature Test, Section 16, are to be used for this test. The connector surface is to be wrapped in foil and serve as the outer electrode. See 18.2.1.

17.3 To determine that a spring-action connector complies with 17.1, the connector is to be tested by means of a suitable 500-volt-ampere or larger capacity transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

18 Dielectric Voltage-Withstand Test

18.1 General

18.1.1 An insulated wire connector shall withstand the dielectric voltage-withstand tests indicated in Table 18.1.

18.1.2 No sample is to be subjected to more than one dielectric voltage-withstand test. However, when agreeable to those concerned, samples may be subjected to more than one test. Samples tested in Test A, Insulation Puncture, may be used for Test B, Flashover.

18.1.3 For a connector intended to secure combinations of conductors of different total cross-sectional area, or one that accommodates only a single conductor of different AWG sizes in a single hole, the entire specified series of tests is to be repeated. For one series, samples of the connector are to be secured to the combination of conductors of the smallest total cross-sectional area, or to the smallest conductor, when only one conductor is intended to be secured in an opening; and for the second series the samples are to be secured to the combination of largest total cross-sectional area, or to the largest conductor when only one conductor is intended to be secured in an opening.

18.1.4 In addition to the combinations specified in 18.1.3, the following combinations are to be tested for a twist-on wire connector only:

a) The conductor combination having the maximum fill (see 6.5.2); and

b) The largest total number of conductors (any combination of sizes).

The conductor insulation shall comply with 7.2.7.

18.1.5 When the connector has multiple voltage ratings, it is to be determined whether more than one set of tests is required.

Table 18.1
Dielectric voltage-withstand test sequence

Connector construction		Required tests[a]
I.	A connector having insulation in the form of a tubular sleeve and intended to accommodate only one conductor in each opening[b] and intended for use with:	
	(1) No. 10 AWG (5.3 mm^2) or smaller conductors	A, C
	(2) Nos. 8 – 6 AWG (8.4 – 13.3 mm^2) conductors	A
II.	Insulated connectors not covered in Item I[c].	A, B

[a] A – Test A is described in 18.2.1 – 18.2.3 and Tables 18.2 and 18.3.
B – Test B is described in 18.3.1 and Table 18.4.
C – Test C is described in 18.4.1.

[b] These types of connectors include insulation-piercing and push-in types.

[c] These types of connectors include twist-on types.

Table 18.2
Required tests and samples

Insulating material	Number of samples[a]
Thermosetting – for example, porcelain, cold-molded melamine, phenolic or urea-compound:	
Test as received only	6
Thermoplastic – for example, vinyl or nylon:	
Test as received	6
Test after oven conditioning, with samples assembled to conductors before such conditioning[b]	6
Test after oven conditioning, with samples assembled to wire after such conditioning[c]	6

[a] See 18.1.2.

[b] See 18.2.2 and Table 18.3.

[c] See 18.2.3.

Table 18.3
Oven-conditioning specifications

Insulation temperature rating		Oven temperature			
		168 Hour test		Optional 1440 hour test	
°C	(°F)	°C	(°F)	°C	(°F)
75	(167)	113	(235)	81	(178)
90	(194)	121	(250)	97	(207)
105	(221)	136	(277)	113	(235)
125	(257)	158	(316)	133	(271)
150	(302)	180	(356)	158	(316)

18.2 Test A, insulation puncture

18.2.1 The tests to be conducted and the number of samples for each test are to be as specified in Table 18.2. Six different samples are to be used for each test. The test potential is to be 2200 volts for a connector rated 300 volts and is to be 3400 volts for a connector rated 600 volts [1000 volts for lighting signs and fixtures (luminaires)]. Each sample is to be connected to a conductor or conductors in the intended manner and the test potential is to be applied for 1 minute between the conductor or conductors and an outer electrode. Each sample is to be embedded in No. 7-1/2 conductive shot. A smaller than No. 7-1/2 (higher size number) shot shall be used with concurrence of those concerned. The conductive shot is to serve as the outer electrode; except that for a connector employing a separable cap that is applied after assembly of the connector to the conductor and has openings that cannot be effectively closed to prevent entry of the shot, metal foil, closely applied to the outer surface of the insulation, is to be used as the outer electrode. Only that portion of the outer insulating surface that covers live parts is to be covered with the outer electrode. A connector that has openings that requires the entrance of shot, thereby possibly resulting in flashover, is to have those openings closed with tape, petrolatum, epoxy, silicon, rubber, or other intended material. The supplementary insulating material is not to be so applied as to supplement the connector insulation where it covers live parts. Puncture of the conductor insulation during this test is not capable of being used. When flashover between the electrode and a normally insulated live part should occur, the supplementary insulation is to be repaired and the test is to be repeated.

18.2.2 With reference to (b) of Table 18.2, six samples previously assembled to conductors are to be conditioned in an air-circulating oven in accordance with Table 18.3.

18.2.3 With reference to (c) of Table 18.2, the samples not previously connected to conductors are to be conditioned for 168 hours in an air-circulating oven at 100°C (212°F). Connectors employing extended covers or sleeves may have wires pre-inserted, but not crimped, prior to the oven aging. The samples are required to cool to room temperature. Samples of a hygroscopic material such as nylon are then to be conditioned for 24 hours at a relative humidity of 85 ±5 percent at 30 ±2°C (86 ±4°F). All samples are then to be connected (or crimped) to conductors in the intended manner.

18.3 Test B, flashover

18.3.1 Six samples are to be tested in the as-received condition. See 18.1.2. Each sample is to be wired as intended. The applicable value of test potential specified in Table 18.4 is to be applied for 1 minute, and the potential is to be rapidly and steadily increased to some value higher than the maximum value specified in Table 18.4 – but breakdown at a value higher than the specified maximum is not unacceptable – and is to be immediately removed. At the manufacturer's option, after being held at the required test potential for 1 minute, the potential is capable of being reduced to zero and then rapidly and steadily increased to the higher potential. The potential is to be applied between a conductor secured by the connector and an outer electrode. A connector having insulation in the form of a cap is to be embedded to the edge of the caps in No. 7-1/2 conductive shot. A smaller than No. 7-1/2 (higher size number) shot is to be used with concurrence of those concerned. The conductive shot is to serve as the outer electrode. Any other connector is to have the surface immediately adjacent to the conductor opening covered with metal foil to serve as the outer electrode. When flashover from the outer electrode to a normally insulated live part of the connector or insulation puncture occurs, the test is to be repeated. Flashover between the conductor and the outer electrode is not capable of being used.

Table 18.4
Test voltage

Connector rating, volts	Test potential, volts	
	1-Minute	Maximum
300	2200	4000
600 (1000 in signs and fixtures)	3400	8000

18.4 Test C, flashover

18.4.1 Six samples are to be tested in the as-received condition. See 18.1.2. The test potential is to be 1600 volts for a connector rated 300 volts, 3000 volts for a connector rated 600, 1000 volts in signs and lighting fixtures (luminaires), and is to be applied for 1 minute. Each sample, not assembled to a conductor or conductors, is to be placed on a flat metal plate in a position most likely to result in breakdown to the open end when the test potential is applied between the metal plate and all insulated metal parts of the connector. A breakdown (flashover) is not intended.

19 Secureness-of-Insulation Test

19.1 For other than a connector as described in 19.2, the insulation of a connector shall not be damaged and shall not become detached from the body of the connector when a pull of 20 pounds (89 N) is applied for 1 minute between the insulation and the connector.

19.2 Connector insulation in the form of a tubular sleeve and intended for use with No. 10 AWG (5.3 mm^2) or smaller conductors shall not be damaged and shall not become detached from the body of the connector when a pull is applied for 1 minute between the insulation and connector as described in 19.3.

19.3 The test is to consist of applying:

a) A 1-pound (4.5 N) pull on an unassembled as-received sample and on an unassembled sample after oven conditioning in accordance with Table 18.3; and

b) A 5-pound (22.2 N) pull on an assembled as-received sample, on a sample that has been assembled to a conductor before oven conditioning according to Table 18.3, and on a sample that has been connected to the conductor after oven conditioning at 100°C (212°F) in accordance with 18.2.3.

In regards to testing connectors that are assembled to conductors as specified in (b), only the maximum and minimum size conductors rated for the connectors under test are to be used.

19.4 With reference to the requirements in 19.1 and 19.2, a temporary distortion of flexible insulating material during the test is considered capable of being used. Tearing or breaking of the insulation is intended when the results of a repeated dielectric voltage-withstand test are intended. The variety of designs of connectors is such that it is not required to specify in detail how the pull is to be applied; therefore, the arrangement is to be such that the tendency for the insulation to be damaged or to be separated from the body is greatest.

19.5 A connector having flexible insulation that is assembled to the body of the connector after the latter is connected to a conductor or conductors is not to be subjected to the test specified in 19.1 until after the insulation has regained its normal shape after being assembled to the connector.

20 *Reserved*

21 Flexing Test

21.1 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 described in 21.2.

21.2 The flexing test is to be conducted on insulating covers in the as-received condition, after oven conditioning according to Table 18.3, and after conditioning at minus 10°C (14°F) for 2 hours. The samples conditioned at minus 10°C are to be required to attain room temperature after removal from the cold box before the flexing test is conducted. Six samples are to be tested for each condition. The samples are to be assembled with the combination of conductors of the largest total cross-sectional area. The insulating cover is to be completely opened and closed 20 times. When flexible extensions are provided around the cables, the cables are also to be flexed 20 times. Distortion of the flexible extensions is intended when, after 24 hours, they return to their original shape and position.

22 Moisture-Absorption Test

22.1 Porcelain or cold-molded composition used as insulation on connectors shall not absorb more than 3 percent of its weight when tested as described in 22.2.

22.2 Samples used for the Moisture Absorption Test are to be clean and dry. The insulation on the connector is to be broken, weighed, and then submerged in distilled water at room temperature for 24 hours. After removal from the water, the broken insulation is to be dried with a soft cloth to remove all surface water and immediately reweighed.

23 10-Day Moist Ammonia-Air Stress Cracking Test

23.1 After being subjected to the conditions described in 23.2 – 23.4, a brass part containing more than 15 percent zinc shall not show evidence of cracking when examined using 25X magnification.

23.2 Each test sample is to be subjected to the physical stresses normally imposed on or within a part as the result of assembly. Such stresses are to be applied to the sample prior to and maintained during the test. Samples shall be assembled to a 6-inch (152-mm) length of the maximum rated size conductor and torqued to the value specified in 7.4.3.

23.3 Three samples are to be degreased and then continuously exposed in a set position for ten days to a moist ammonia-air mixture maintained in a glass chamber 12 by 12 by 12 inches (305 by 305 by 305 mm) having a glass cover.

23.4 Aqueous ammonia measuring 600 ml and having a specific gravity of 0.94 is to be maintained at the bottom of the glass chamber below the samples. The samples are to be positioned 1-1/2 inches (38.1 mm) above the aqueous ammonia solution and supported by an inert tray. The moist ammonia-air mixture in the chamber is to be maintained at atmospheric pressure and a temperature of 34 ±2°C (93 ±4°F).

24 Installation at Low Temperature

24.1 Insulated wire connectors having insulation of a thermoplastic or thermosetting material, except those which are intended solely for factory installation, shall be capable of being installed in the intended manner while maintained at a temperature of 0 ±1°C (32 ±34°F) without cracking or fracture in the insulation.

Effective date for 24.1 changed from September 28, 2000 to October 10, 2006

24.2 For this test the connectors, short lengths of wires, and the necessary tools shall be placed in a cold chamber for enough time to require all of the parts to reach a uniform temperature of 0 ±1°C (32 ±34°F). The installation of the connectors on the wires shall be performed in the cold area and the specimens then removed from the cold chamber and examined for evidence of damage.

MARKING

25 Details

25.1 For the purpose of the marking requirements, containers are defined as follows:

a) Unit Container – The smallest container in which connectors are packaged.

b) Packaging Container – The container in which the unit containers are packaged.

25.2 Markings shall be located as indicated in Table 25.1.

Table 25.1
Marking locations

Revised Table 25.1 effective October 10, 2006

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.3	General marking:			
	a) Manufacturer's name	X	–	–
	b) Catalog number	X	–	–
	c) Conductor size or range of sizes	X	–	–
25.4	Manufacturer's identification may be a traceable code	X	–	–
25.4	25.3(a) and (b) may be marked with single identifying symbol	X	X	X
25.3	25.3(c) not on connector if connector accommodates two or more conductors in same opening	–	X	–
25.5	For single conductor in an opening, type of wire conductor and if insulated, voltage and operating temperature ratings	X	X	X

Table 25.1 Continued on Next Page

Table 25.1 Continued

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.6	For two or more conductors in the same opening, type of wire conductors and wire conductor combinations and if insulated, voltage and operating temperature ratings	–	X	X
25.7	For all connectors, ″TO BE SOLD ONLY WITH INSTALLATION INSTRUCTIONS″	–	X	X
25.8	Not for use with THW wire	–	X	X
25.9	For connectors for use with AL conductor of one size or range of sizes and CU conductor of a different size or range of sizes, conductor-size marking indicates size or range of sizes for which connector is acceptable	X	X	X
25.10	″Solid″ or ″Stranded″ or both as appropriate	X	X	X
25.11	For connectors tested with conductors other than Class B and Class C stranding, marking indicates conductor class or classes and the number of strands	X	X	X
25.12	Abbreviations ″Sol.″ and ″Str.″	X	X	X
25.13	Rearrangement or adjustment necessary to adapt to various sizes	X	X	X
25.13	Procedure for proper assembly: specific tool, multiple crimping operations, conductor strip length, preliminary preparation of conductor	X	X	X
25.15	Identification for selection and proper use of tool. See 25.14.	X	X	X
25.16	25.3(a) and (b) marked on unit container or information sheet	–	X	X

Table 25.1 Continued on Next Page

Table 25.1 Continued

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.17	For a separable cover of a splicing connector, manufacturer's name, catalog number, voltage rating, operating temperature	X	X	X
25.18	For a separable cover, voltage rating and operating	–	X	–
25.18	For a separable cover of a ceramic, twist-on connector, operating temperature not marked	–	–	–
25.20	For a tool applied crimp-on connector for multiple conductors, ″Pretwist Wires Before Crimping″	X	X	X
25.20	For a connector that does not lend itself to direct contact, 25.20marking not required	–	–	–
25.20	For a connector that has a C or H configuration or permits conductors to be directly laid into opening, 25.20marking not required	–	–	–
25.21	″OEM″ Marking/ No pretwisting for OEM applications	X	X	X
25.24	Flammability (optional)	X	X	X
NOTE – These are brief summaries of marking requirements. For complete details, see the specific Marking reference.				

25.3 A connector shall be legibly and permanently marked with:

a) The manufacturer's name, trade name, or trademark or other descriptive marking by which the organization responsible for the product may be 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.

25.4 With reference to 25.3(a), when the manufacturer's identification is in a traceable code, the product shall be identified by the brand or trademark owned by a private labeler. In lieu of the requirements in 25.3 (b) and (c), a connector marked with a single identifying symbol is acceptable. A symbol consisting of an individual catalog number, a type designation, a size designation, such as 12, or an equivalently significant symbol is acceptable. Each unit container containing connectors so identified or an information sheet packed in the unit container shall be marked with the information indicated in 25.3(a), (b), and (c). A type designation is intended primarily to identify a particular design, which includes various features covered by different catalog numbers.

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

a) ″AL ″ for aluminum conductor only;

b) ″CU ″ for copper conductor only;

c) ″AL-CU ″ or ″CU-AL ″ for aluminum and copper conductor;

d) With the appropriate voltage rating – ″600 volts ″ or ″300 volts ″ – for which the insulated connector has been found capable of being used (see 25.17); and

e) With the operating temperature rating for which the insulated connector has been found capable of being used. See also 25.17.

25.6 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:

a) ″CU ″ for copper conductor only;

b) ″AL ″ for aluminum conductor;

c) ″AL-CU ″ or ″CU-AL ″ for copper to copper, 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;

e) With the appropriate voltage rating – ″300 volts maximum,″ ″600 volts maximum,″ or ″600 volts maximum building wire; 1000 volts maximum signs or lighting fixtures (luminaires),″ or equivalent wording – for which the insulated connector has been found capable of being used. The word ″(luminaires)″ is not prohibited.

f) With the operating temperature rating for which the insulated connector has been found capable of being used. See also 25.17.

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

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

Effective date for 25.7 changed from September 28, 2000 to October 10, 2006

25.8 Twist-on connectors tested with conductors in accordance with Exception 2 or 7.2.7 shall be marked ″not for use with type THW wire″ or equivalent on the unit container of information sheet contained within the unit container.

Effective date for 25.8 changed from September 28, 2000 to October 10, 2006

25.9 When 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 indicate plainly the size or range of sizes of the conductors for which the connector is intended.

25.10 A connector tested with solid or stranded conductor other than as indicated in 6.1.2 shall be marked ″Solid ″ or ″Stranded ″ or with both markings as appropriate. See 25.12.

25.11 A connector, a unit container, or an information sheet packed in the unit container for a connector tested with conductors other than Class B and Class C stranding (see 1.4 and 7.2.2) shall also be marked with the conductor class or classes and the number of strands.

25.12 The ″Solid″ and ″Stranded″ markings specified in 25.10 and 25.11:

a) Shall be abbreviated ″Sol.″ and ″Str.″ respectively, to fit in a limited area on the connector; or

b) Shall be printed on the unit container or on an information sheet packed in the unit container, only when there is no space on the connector for either the complete or the abbreviated marking.

25.13 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 the connector.

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

a) Use of a Specific Tool Required – When a connector is intended to be connected to a conductor or conductors by a specific tool, the tool designation or the designation of a removable tool part such as a pressing die shall be marked:

1) On the connector; or

2) On the unit container or information sheet in which the connector is packed by at least one of the following markings:

i) Catalog or type designation;

ii) Color coding;

iii) Die index number; or

iv) Other equivalent means.

b) Multiple Crimping Operations Required – Information shall be provided:

1) On the unit container or on an information sheet packed in 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, shall be marked on the connector when the additional required information is located as indicated in (1), (2) or (3).

c) Conductor Strip Length – Strip length marking as specified in Table 25.2 shall be provided:

1) On the unit container or on an information sheet packaged in the unit container in which the connector is packed;

2) On the connector;

3) On an insulation cover; or

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

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 be provided:

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

2) On an information sheet packed in the unit container; or

3) On the carrying case provided for permanent storage of the tool. See 5.4, 7.2.1, and 25.20.

Table 25.2
Required conductor strip length marking

Connector type	Maximum strip length[a]	Minimum strip length[a]
Insulated	X[b,c]	X[b,c,d]
Noninsulated	–	X[b,c,d]

[a] Indicates marking is required.

[b] Strip length may be specified as a single – nominal – value when tested as specified in 7.3.2.

[c] Strip length marking not prohibited when 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.

[d] Strip length marking not prohibited when connector is provided with an inspection hole opposite the conductor insertion end and through which the end of the conductor is visible after it is connected.

25.15 A specific tool and a removable part of such a tool, such as a pressing die, shall be permanently marked with an identification that is used for the selection and the proper use of the tool. See 25.14.

25.16 A unit container or an information sheet shall be marked with the following:

a) Manufacturer's name; and

b) A distinctive catalog number of the connector or the equivalent when the marking is provided as specified in 25.19.

25.17 A separable cover of splicing connector shall be marked with the following:

a) Manufacturer's name;

b) A distinctive catalog number or the equivalent;

c) The voltage rating; and

d) The operating-temperature limit for the insulating material of the connector. See also 25.5 and 25.6 and Table 25.3.

25.18 The operating temperature limit specified in 25.17(d) is not required to be marked for a ceramic, twist-on connector. The voltage rating, 25.17(c), and operating-temperature limit, 25.17(d), shall be marked on the unit container when such container is also marked as specified in 25.17(a) and 25.17(b).

Table 25.3
Acceptable temperature of insulation

Material	Temperature	
	°C	(°F)
Thermoplastic[a]	75	(167)
	90	(194)
	105	(221)
	125	(257)
	150	(302)
Phenolic[b]	150	(302)
Urea[c]	100	(212)
Melamine[d]	130	(266)
Melamine[e]	150	(302)

[a] To be 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.

25.19 When any of the required markings specified in 25.4, 25.5, 25.7, 25.9, 25.12(b), 25.13, 25.14, 25.17, 25.20, 25.21, and 25.24 are placed on the unit container or on the information sheet packed in the unit container, then all such markings in their entirety shall be so placed. The information in a marking shall not be divided between a unit container and an information sheet.

25.19 revised October 10, 2001

25.20 A tool applied crimp-on connector for multiple conductors shall be marked with the following or equivalent: ″Pretwist Wires Before Crimping.″ Illustrations showing multiple-twisting internal to the body of the connector is capable of being used when used in conjunction with the marking. See 25.19. A connector that does not lend itself to direct contact, such as a butt-end splice connector, is not required to be marked. A connector that has a C or H configuration or permits a conductor to be directly laid into the opening is not required to be marked.

25.21 A connector tested according to 5.5 shall be marked with the letters ″OEM.″ When marketed for field wiring applications, the marking described in 25.20 is still required. See 25.19. 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 pretwising when used in OEM applications.″

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

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

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

b) The letter ″f″ for flexible.

25.24 In addition to the required markings, the manufacturer is able to mark the flammability classification of the insulating material on the connector, smallest unit container, or on an information sheet placed in the smallest unit container. See 4.7.

25.24 added October 10, 2001

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Superseded requirements for
the Standard for
Splicing Wire Connectors

UL 486C, Fourth Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

4.9 Insulated twist-on or set-screw connectors rated for aluminum shall have insulation colored purple or brown. An insulated twist-on or set-screw connector rated for copper wire only shall not be colored purple or brown.

7.2.7 With reference to 6.5.1 and 18.1.4, the insulation shall be black and have a nominal thickness as stated in Table 7.1.

Exception: Insulation colored other than black may be used if agreeable to those concerned.

7.2.9 The test and the control conductors are to be as follows. See also 7.2.4 – 7.2.7 and Table 7.2.

a) Aluminum:

1) Solid – No. 12 AWG (3.3 mm^2) and larger, complying with the requirements for aluminum wire stock intended as an electrical conductor.

2) Stranded – Nos. 12 – 6 AWG (3.3 – 13.3 mm^2), reverse lay concentric or compressed Class B stranding, aluminum designation 1350-H19 (ASTM B230) or 1350-H16 or 1350-H26 (ASTM B609), and having an iron content of 0.4 percent maximum.

b) Copper:

1) Solid and Stranded – Nos. 30 – 16 AWG (0.05 – 1.3 mm^2) soft annealed, tinned or untinned.

2) Solid – No. 14 AWG (2.1 mm^2) and larger, soft annealed, and untinned.

3) Stranded – Nos. 14 – 10 AWG (2.1 – 5.3 mm^2) soft annealed, and untinned. The stranding is to be concentric or compressed Class B or concentric Class C. See 7.2.2.

4) Stranded – Nos. 8 – 6 AWG (8.4 mm^2 – 13.3 mm^2). The stranding is to be compact Class B. See Table 7.2.

Table 7.2
Conductor for test

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

[a] Number of strands may vary.

Table 9.1
Test current for copper and aluminum conductors, amperes

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

NOTE – Values are for 75°C single conductor in free air ampacities, National Electrical Code, ANSI/NFPA 70-1999.

[a] See and .

Table 11.1
Test values

Size of conductor		Diameter of bushing hole[a]		Height[b]		Weight, pounds (kg)			
AWG	(mm^2)	Inches	(mm)	Inches	(mm)	Copper		Aluminum	
18	(0.82)	1/4	(6.4)	10-1/4	(260)	1	(0.45)	–	
16	(1.3)	1/4	(6.4)	10-1/4	(260)	1	(0.45)	–	
14	(2.1)	3/8	(9.5)	11	(279)	1.5	(0.7)	–	
12	(3.3)	3/8	(9.5)	11	(279)	2.5	(1.15)	1.5	(0.7)
10	(5.3)	3/8	(9.5)	11	(279)	2.5	(1.15)	1.5	(0.7)
8	(8.4)	3/8	(9.5)	11	(279)	4	(1.8)	3	(1.4)
6	(13.3)	1/2	(12.7)	11-3/4	(298)	9	(4.1)	9	(4.1)

[a] When a hole with the diameter given is not adequate to accommodate the conductor without binding, a bushing having a hole of slightly larger diameter is not prohibited from being used.

[b] For Nos. 12 – 6 AWG aluminum conductor, use 12-1/2 inches (318 mm).

Table 25.1
Marking locations

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.3	General marking:			
	a) Manufacturer's name	X	–	–
	b) Catalog number	X	–	–
	c) Conductor size or range of sizes	X	–	–
25.4	Manufacturer's identification may be a traceable code	X	–	–
25.4	25.3(a) and (b) may be marked with single identifying symbol	X	X	X
25.3	25.3(c) not on connector if connector accommodates two or more conductors in same opening	–	X	–
25.5	For single conductor in an opening, type of wire conductor and if insulated, voltage and operating temperature ratings	X	X	X
25.6	For two or more conductors in the same opening, type of wire conductors and wire conductor combinations and if insulated, voltage and operating temperature ratings	–	X	X

Table 25.1 Continued on Next Page

Table 25.1 Continued

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.7	For all connectors, ″TO BE SOLD ONLY WITH INSTALLATION INSTRUCTIONS″	–	X	X
25.9	For connectors for use with AL conductor of one size or range of sizes and CU conductor of a different size or range of sizes, conductor-size marking indicates size or range of sizes for which connector is acceptable	X	X	X
25.10	″Solid″ or ″Stranded″ or both as appropriate	X	X	X
25.11	For connectors tested with conductors other than Class B and Class C stranding, marking indicates conductor class or classes and the number of strands	X	X	X
25.12	Abbreviations ″Sol.″ and ″Str.″	X	X	X
25.13	Rearrangement or adjustment necessary to adapt to various sizes	X	X	X
25.13	Procedure for proper assembly: specific tool, multiple crimping operations[f], conductor strip length[f], preliminary preparation of conductor[f]	X	X	X
25.15	Identification for selection and proper use of tool. See 25.14.	X	X	X
25.16	25.3(a) and (b) marked on unit container or information sheet	–	X	X
25.17	For a separable cover of a splicing connector, manufacturer's name, catalog number, voltage rating, operating temperature	X	X	X
25.18	For a separable cover, voltage rating and operating	–	X	–

Table 25.1 Continued on Next Page

Table 25.1 Continued

Marking reference	Required marking	Location		
		Connector	Unit container	Information sheet
25.18	For a separable cover of a ceramic, twist-on connector, operating temperature not marked	–	–	–
25.20	For a tool applied crimp-on connector for multiple conductors, ″Pretwist Wires Before Crimping″	X	X	X
25.20	For a connector that does not lend itself to direct contact, 25.20marking not required	–	–	–
25.20	For a connector that has a C or H configuration or permits conductors to be directly laid into opening, 25.20marking not required	–	–	–
25.21	″OEM″ Marking/ No pretwisting for OEM applications	X	X	X
25.24	Flammability (optional)	X	X	X
NOTE – These are brief summaries of marking requirements. For complete details, see the specific Marking reference.				

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