UL 486B

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Wire Connectors for Use with Aluminum Conductors

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Wire Connectors for Use With Aluminum Conductors, UL 486B

Fourth Edition, Dated February 26, 1997

Revisions: This Standard contains revisions through and including May 23, 2001.

UL is in the process of converting its Standards for Safety to the Standard Generalized Markup Language (SGML), and implementing an SGML compliant document management and publishing system. SGML - an international standard (ISO 8879-1986) - is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Significant benefits that will result from UL's use of SGML and these new systems include increased productivity, reduced turnaround times, and data and information consistency, reusability, shareability, and portability. However, the fonts, pagination, and general formatting of UL's new electronic publishing system differ from that of UL's previous publishing system. Consequently, when revision pages are issued for a Standard with the new publishing system, these differences may result in the printing of pages on which no requirements have been changed - these additional pages result from relocation of text due to repagination and reformatting of the Standard with the new publishing system.

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.

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 May 23, 2001 include a reprinted title page (page1) for this Standard.

Tables 7.4, 13.1, and 14.2 on pages dated May 22, 2000 have been marked changed as a result of UL's electronic publishing process. This change is editorial and for appearance only. No change has been made to the values in the tables.

The revisions dated June 25, 1997 was issued to correct a typographical error in Table 9.1 for the heat cycling test current for No. 4 AWG, 75°C rating.

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, Recognition 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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FEBRUARY 26, 1997
(Title Page Reprinted: May 23, 2001)

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UL 486B

Standard for Wire Connectors for Use With Aluminum Conductors

First Edition – August, 1978
Second Edition – April, 1982
Third Edition – October, 1991

Fourth Edition

February 26, 1997

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

The Department of Defense (DoD) has adopted UL 486B on June 22, 1992 . The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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

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

INTRODUCTION

1 Scope

1.1 These requirements apply to pressure wire connectors intended for use with aluminum or copper-clad aluminum conductor or both according to the National Electrical Code, NFPA 70. The connectors may be constructed so that they are also acceptable for use with copper conductor.

1.2 These requirements also cover ampere-rated connectors intended for use in appliances and equipment and that comply with the requirements specific to those appliances and equipment. Ampere-rated connectors are not intended for general use. Ampere-rated connectors are additionally evaluated for static temperature rise in the end-use application. Ampere-rated connectors shall be identified as such by the appropriate marking requirements. See 21.21.

1.3 These requirements cover:

a) Terminal-type wire connectors intended for use with No. 12 AWG (3.3 mm^2) or larger aluminum or copper-clad aluminum conductor, including those designated also for No. 30 AWG (0.05 mm^2) or larger copper conductor, and

b) Splicing-type wire connectors intended for use with No. 4 AWG (21.2 mm^2) or larger conductors, with currents not exceeding the ampacity of insulated conductors rated 75°C or 90°C in accordance with the connector rating and not exceeding the maximum current rating – if provided – of the connector. A splicing connector may have a conductor range that includes sizes smaller than No. 4 AWG. For connectors intended for use with stranded conductors, the following conductor strand configurations are intended:

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

2) Copper – Class B concentric and compressed, Class C concentric.

3) Copper-Clad Aluminum – Class B concentric.

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

1.3.1 These requirements also cover connectors of the types specified in 1.3 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 6.1.13, 7.2.2.1, 21.26, and 21.27.

1.3.1 added May 22, 2000

1.4 These requirements cover insulated connectors, insulating caps, and covers intended for use at 600 volts or less [1000 volts in a sign or lighting fixture (luminaire)] and uninsulated connectors for use in general-use circuits rated 2000 volts nominal or less.

Exception: Uninsulated pressure wire connectors (both terminal and splicing type) that are compression tool applied may be used in circuits rated 35,000 volts or less. When connectors are used in such circuits, the stress-relief insulation prescribed by the manufacturers of shielded cables is to be provided when these connectors are installed.

1.5 These requirements also cover connectors additionally rated for No. 2 AWG (33.6 mm^2) and larger compact-stranded copper conductors. These connectors are identified in accordance with 21.8. See also 3.2 and the Exception to 7.2.7(b) (3).

1.5 revised May 22, 2000

1.6 These requirements do not cover connectors intended for direct burial, insulated connectors intended for use at voltage levels in excess of 600 volts [1000 volts in a sign or lighting fixture (luminaire)], manually applied screw-on connectors, binding-screw terminals, built-in terminal connectors on devices rated under 30 amperes and intended for outlet-box mounting or having provision for strain relief, or built-in terminal connectors on devices having integral cable clamps.

1.7 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.

1.7 revised May 22, 2000

2 General

2.1 Units of measurement

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

2.1.1 revised May 22, 2000

2.2 Undated references

2.2.1 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 The construction of a connector intended for use with stranded conductor shall be such that all strands of the conductor will be contained within the connector.

3.2 A connector tested with a compact stranded aluminum and/or copper conductor according to these requirements shall also accept all strands of a Class B concentric stranded conductor of the same size and type.

3.3 The clamping movement of a connector shall adapt it for use with conductors of different sizes without permanent removal or addition of parts, when such use is intended. 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) Deformation of the connector barrel – crimping – using a specific tool, or

d) A nut threading onto a split bolt.

Any rearrangement or adjustment of a connector that is necessary to adapt it to various sizes of the conductor shall be obvious unless the connector is marked as required by 21.6.

3.4 If the method of mounting an equipment terminal connector is such that the mounting means cannot be retightened after conductors are installed, or after the connector is mounted in equipment, the mounting means – by inherent features or manufacturer's specifications – shall limit rotation of the connector around its mounting means to 30 degrees maximum.

3.5 There shall be no sharp edges or corners on the outer surface of a connector that would be likely to damage insulation that it may contact.

3.6 The construction of a connector intended to secure more than a single conductor shall be such that there will be no intermixing (direct contact) between the conductors of different materials unless the connector is investigated and marked for intermixing - dry locations only. See 6.1.12, 6.2.3, 6.3.2, and 21.5.

3.6 effective October 16, 1998

4 Materials

4.1 The main current-carrying part of a connector shall be of aluminum, an aluminum alloy, copper, a copper alloy, or other material investigated and found to be acceptable for the purpose.

4.2 A connector body of copper, copper alloy, aluminum, or aluminum alloy shall be coated with an electrically conductive coating that will inhibit oxidation and corrosion.

Exception No. 1: A splicing connector that is shipped prefilled with an oxide-inhibiting compound need not be coated.

Exception No. 2: The conductor securing (barrel) portion of a terminal connector that is shipped prefilled with an oxide-inhibiting compound need not be coated.

Exception No. 3: An aluminum bodied splicing connector intended for an aluminum conductor only; not copper-clad aluminum need not be coated.

Exception No. 4: The saw-cut ends of a neutral bar need not be coated.

Exception No. 5: The top cap of a lay-in lug or connector not in contact with the wire need not be plated.

Exception No. 6: A stamped mounting hole in a connector which is intended to be secured by a bolt, nut, and washer need not be plated.

4.3 Tin is acceptable for the coating mentioned in 4.2. Other coatings may be acceptable if found by investigation to be acceptable for the purpose.

4.4 A brass part of a connector shall be resistant to stress corrosion cracking.

4.5 A brass part containing not more than 15 percent zinc is considered to be resistant to stress corrosion cracking.

4.6 A brass part containing more than 15 percent zinc shall comply with 10-Day Moist Ammonia-Air Stress Cracking Test, Section 20.

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

4.8 Insulation employed as a part of a connector shall be porcelain, cold-molded or phenolic composition, or other material that has been investigated and found to be acceptable for 75°C or 90°C according to the intended use of the connector. See 21.16.

4.8.1 The insulating material is able to have a flammability classification as determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. See 21.28.

4.8.1 added May 23, 2001

4.9 Insulation consisting of natural or GR-S rubber or a thermoplastic material may be subjected to an appropriate investigation to determine if it is acceptable for the purpose.

4.10 Porcelain or cold-molded composition used as insulation shall additionally comply with Moisture Absorption Test, Section 19.

PERFORMANCE

5 General

5.1 A connector shall perform acceptably when separate sets of samples are subjected to the tests specified in Tables 5.1 – 5.3.

Exception No. 1: A connector of copper or copper alloy need not be subjected to the heat-cycling sequence with copper conductor.

Exception No. 2: The initial static-heating test need not be conducted in the static-heating sequence using copper conductor.

Exception No. 3: For other than a tool-applied crimp connector, the heat-cycling test using copper conductor need not be conducted provided the connector has been heat-cycling tested with aluminum conductor of a size not smaller than the size of copper conductor which would otherwise be required for the heat-cycling test.

> *Example No. 1: A setscrew connector is rated 4 AWG – 250 kcmil CU/AL. The conductor sizes required for heat-cycling testing are 250 kcmil CU and 250 kcmil AL. In accordance with Exception No. 3 above, the heat-cycling test using copper conductor need not be conducted because the size of aluminum conductor to be heat-cycling tested is not smaller than the size of*

copper conductor.

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Example No. 2: A setscrew connector is rated 4 AWG – 250 kcmil CU, 4 – 1/0 AWG AL. The conductor sizes required for heat-cycling testing are 250 kcmil CU and 1/0 AWG AL. As the size of aluminum conductor to be tested is smaller than the size of copper conductor, Exception No. 3 above would not apply and the heat-cycling test would need to be conducted for both copper and aluminum conductor.

Exception No. 4: Nos. 30 – 20 AWG (0.05 – 0.52 mm^2) conductors need not be subjected to the secureness test.

Table 5.1
Test sequence for insulated connectors

1	2	3[a]	4
Dielectric voltage- withstand	Secureness of insulation	Drop dielectric voltage- withstand after drop	Flexing
[a] Connectors intended for No. 2 AWG (33.6 mm^2) or larger conductor.			

Table 5.2
Test sequence for all connectors intended for a single conductor

1	2[a]	3[b]
Heat cycling	Static heating secureness[c] static heating pullout	Secureness[c] pullout
[a] This series of tests is referred to as static-heating sequence.		
[b] This series of tests is referred to as mechanical sequence.		
[c] Conductor size Nos. 30 – 20 AWG (0.05 – 0.52 mm^2) are not subject to a secureness test.		

Table 5.3
Test sequence for all connectors intended for paralleling conductors

Static heating	Heat cycling	Secureness[a] pullout
[a] This series of tests is referred to as mechanical sequence.		

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, shearing of parts, or other 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.

5.3 With reference to 5.2, 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. If the conductor or a strand of a stranded conductor becomes visibly unattached, breakage is considered to have occurred.

5.4 The oven conditioning described in 14.2.2 and 14.2.3 and Table 14.3 shall not cause the connector insulation to harden, soften, crack, deform, loosen, or otherwise change so as to adversely affect the insulating properties of the conductor insulation or the connector insulation. However, discoloration of the connector insulation is acceptable.

6 Selection of Samples

6.1 General

6.1.1 Separate samples are to be used for the heat-cycling, mechanical sequence, static-heating sequence, and the dielectric voltage-withstand test.

6.1.2 The basic sample set for heat-cycling tests, mechanical sequence, and static-heating sequence is to consist of four connectors for each combination of connector and test conductor or conductors to be tested.

Exception No. 1: For testing a splicing connector or run and tap connector in which each conductor is secured by a separate means, the sample set is to consist of two connectors for each combination of connector and test conductor to be tested.

Exception No. 2: For a connector intended for a conductor size range of No. 14 – 10 AWG (2.1 – 5.3 mm^2) copper and Nos. 12 and 10 AWG (3.3 and 5.3 mm^2) aluminum, the basic sample set for the static-heating sequence may consist of two connectors for each combination of connector and test conductor to be tested.

Exception No. 3: For a neutral bar, the basic sample set is to consist of a double set of three connector holes cut from a length of the neutral bar. The distance between the holes cut from the neutral bar is to be representative of the minimum distance provided in production. See 11.2.

6.1.3 The number of samples required for the dielectric voltage-withstand tests is specified in Dielectric Voltage-Withstand Test, Section 14.

6.1.4 For a connector intended to be used with aluminum, copper-clad aluminum, and copper conductor (marked ″AL-CU″), sample sets with aluminum conductor and copper conductor are to be subjected to the heat-cycling, static-heating sequence, and mechanical sequence tests. For a connector intended to be used with copper-clad aluminum and copper conductor (marked ″CC-CU″), sample sets with copper-clad aluminum conductor and copper conductor are to be subjected to the heat-cycling, static-heating sequence, and mechanical sequence tests. See exception to 6.2.1.

6.1.5 Tests with aluminum conductor are representative of tests with copper-clad aluminum conductor.

6.1.6 Tests conducted on a connector with unidirectional lay compact stranded conductor are considered to represent tests with Class B concentric and compressed conductor of the same size.

6.1.7 For a line of connectors of similar design but of different sizes in which the largest connector, the smallest connector, and connectors of two representative intermediate sizes have been tested and found to be acceptable, tests are not required to be conducted on other intermediate sizes in the range.

Exception No. 1: For a line of connectors consisting of not more than five sizes, only the largest connector, the smallest connector, and one connector of a representative intermediate size need be tested.

Exception No. 2: For a line of connectors consisting of four or less sizes, only the largest connector and the smallest connector need be tested.

6.1.8 With reference to 6.1.7, in determining what constitutes a line of connectors of similar design, the following features are to be considered.

a) Shape of connector, shape of conductor opening, and shape of conductor clamping screw;

b) Material and surface treatment of connector body;

c) Material of conductor clamping screw;

d) Number of clamping screws;

e) Torque corresponding to the conductor size of each connector in the line;

f) For connectors of use with a crimping tool, crimping die design and number of crimps; and

g) For a tangless connector, the material and plating of the associated tang to be used with the connector.

6.1.9 A connector that is intended to employ clamping screws made of either aluminum, brass, or steel is to be tested with clamping screws made of the materials specified in Table 6.1.

Table 6.1
Material of clamping screw for tests

Screw material	Static and mechanical sequences[a]			Heat cycling[a]		
	Steel	Brass	Aluminum	Steel	Brass	Aluminum
Aluminum, brass, or steel	X	–	X	X	–	X[b]
Aluminum or steel	X	–	X	X	–	X[b]
Brass or steel	X	X	–	X	X[c]	–
Aluminum or brass	–	X	X	–	X[c]	X

[a] An X indicates that the test is to be conducted.
[b] Tests need not be conducted on aluminum screws that are plated and waxed or lubricated, if the temperature for the aluminum screws in the static sequence is less than that for the alternate screw material.
[c] Test need not be conducted if temperature recorded for a brass clamping screw in the static sequence is less than that determined for the alternate screw material.

6.1.10 Sample sets are to be tested using both solid and stranded conductor for No. 30 – 10 AWG (0.05 – 5.3 mm^2) conductor sizes, and using stranded conductor for No. 8 AWG (8.4 mm^2) and larger conductor sizes unless the connector is marked according to 21.9, in which case the conductor used is to be of the type or types marked on the connector.

6.1.11 If the conductor range of a connector includes conductor sizes Nos. 14 – 10 AWG (2.1 – 5.3 mm^2), and these sizes are not included in the test sample selection, additional sample sets are to be tested using maximum size solid conductor in the range of Nos. 14 – 10 AWG.

6.1.12 Sample sets are to be subjected to the test sequences using the conductor material specified in Table 6.2 for the one or more conductor material combinations for which the connector is intended.

Table 6.2
Conductor materials 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-clad aluminum	Copper-clad aluminum
4. Copper to copper[b]	Copper
5. Aluminum to aluminum[b]	Aluminum
6. Copper-clad aluminum to copper-clad aluminum[b]	Copper-clad aluminum
7. Copper to aluminum[b], intermixed	Copper to aluminum
8. Copper to copper-clad aluminum, intermixed[b]	Copper to copper-clad to aluminum

Note –

1) In all test sequences, aluminum conductor represents tests with copper-clad aluminum conductor.

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

3) If a connector is acceptable 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.

6.1.13 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 7.2.2.1.

6.1.13 added May 22, 2000

6.2 Heat cycling

6.2.1 For the heat-cycling test, sample sets are to be tested using the maximum size conductor or conductors – see 6.1.4 – for which a connector without an ampere rating is intended. For a connector intended for a single conductor and also for paralleling conductors, heat-cycling tests are to be conducted on sample sets using the maximum single and maximum parallel conductor sizes. For a connector with an assigned maximum ampere rating, see 6.2.2.

Exception: For a connector that is intended for a range of conductor sizes and for copper conductor in addition to aluminum or copper-clad aluminum conductor, heat-cycling tests with copper conductor need not be conducted if the size that would be selected would result in a test current that is less than or equal to the test current used in the tests with aluminum or copper-clad aluminum conductor. The current used in the tests with aluminum or copper-clad aluminum conductor may be raised above the required value with the concurrence of those concerned.

6.2.2 For a connector with an assigned maximum ampere rating, sample sets are to be tested using the size or sizes – see 6.1.4 – of the conductor corresponding to the assigned temperature and maximum ampere rating of the connector as indicated in Table 9.1. For connectors intended for paralleling conductors – see Exception No. 2 to 6.3.1 for conductor size selection and Table 9.2 for current selection. For a connector with an assigned ampere rating and intended for a single conductor and also for paralleling conductors, the heat-cycling test is to be conducted on sample sets using the conductor combination or conductor size as selected for the Static-Heating Test, Section 10. See Exception Nos. 1 and 2 of 6.3.1.

Exception: For a connector that is intended for a range of conductor sizes and for copper conductor in addition to aluminum or copper-clad aluminum conductor, heat-cycling tests with copper conductor need not be conducted if the size that would be selected would result in a test current that is less than or equal to the test current used in the tests with aluminum or copper-clad aluminum conductor. The current used in the tests with aluminum or copper-clad aluminum conductor may be raised above the required value with the concurrence of those concerned.

6.2.3 With reference to 6.1.12 and (7) and (8) of Table 6.2, if 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. The aluminum conductor mentioned in (a) – (d) may be replaced with copper clad aluminum conductor if that is the only type of aluminum conductor intended to be used with the connector.

a) Maximum size copper with maximum size aluminum.

b) Maximum size copper with minimum size aluminum.

c) Minimum size copper with minimum size aluminum.

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

6.3 Static-heating sequence

6.3.1 For the static-heating sequence – see Tables 5.2 and 5.3 – connectors intended for use with a range of conductor sizes are to be tested with the maximum size conductor. If more than one conductor is secured by a single clamping means, additional sample sets may be necessary. See 11.3.

Exception No. 1: For an ampere-rated connector not intended for paralleling conductors, the static-heating part of the sequence is not to be conducted with the sizes of conductors that are larger than the size conductor that corresponds to the ampere rating of the connector as specified in Table 9.1 – only the mechanical sequence tests are conducted. A connector sample set with the size conductor that corresponds to the ampere rating is to be subjected to the full sequence of static-heating tests. For example, for a connector rated 200 amperes, 250 kcmil – No. 1/0 AWG (127 – 53.5 mm^2), AL-CU, the full sequence of tests are conducted on the 250 kcmil conductor size for aluminum or copper-clad aluminum (315 amperes) and the full sequence is conducted on the No. 3/0 AWG (85 mm^2) conductor size for copper (310 amperes).

Exception No. 2: For an ampere-rated connector intended for paralleling conductors, the static-heating test is not to be conducted with the sizes of conductors that are larger than the size of conductor or conductors that correspond to the ampere rating of the connector – only the mechanical sequence tests are to be conducted. Static-heating tests are to be conducted with the parallel conductor combinations that equal the assigned ampere rating using Table 9.1. When using Table 9.1 for parallel conductors, the ampere rating assigned to the connector is to be divided by the number of conductors. For ampere ratings that fall between two consecutive values the larger conductor size is to be used. The values of test current in the static-heating test for the parallel-conductor range are to be selected from Table 9.3. If the number of conductors is less than the number of conductor openings, the conductors are to be positioned in the connector so that the test current is concentrated in the smallest cross-sectional area of the connector in the current path.
If the connector also has single conductor ranges, the conductor sizes and values of test current in the static-heating tests for the single conductor ranges are to be selected from Table 9.1 using the conductor size that corresponds to the ampere rating of the connector. For example, for a connector rated 400 amperes with two conductor openings and a conductor range of 700 kcmil – No. 2/0 AWG (354 – 67.4 mm^2) marked CU-AL, the required tests are as follows:

Conductor range based on ampere rating for static-heating test selection

Ampere rating	Type of conductor	Conductor range
400	Copper	Single conductor, 700 kcmil–2/0 AWG Two conductors, 3/0 AWG–2/0 AWG
	Aluminum	Single conductor, 700 kcmil–2/0 AWG Two conductors, 250 kcmil–2/0 AWG

Static-heating tests

Number of conductors	Conductor size, AWG or kcmil (mm^2)		Test current, amperes	
			Copper conductor	Aluminum or copper-clad conductor
1	700	(354)	–	595[a]
1	600	(304)	690[a]	–
2	3/0	(85)	400[b]	–
2	250	(127)	–	410[b]
			b	b
			–	b

[a] Selected from Table 9.1.
[b] Selected from Table 9.3.

6.3.2 For the static-heating sequence where intermixing of conductor types is involved, the same selection of samples as indicated in 6.2.3 shall be tested.

6.4 Mechanical sequence

6.4.1 For the mechanical sequence – see Tables 5.2 and 5.3 – connectors intended for use with a range of conductor sizes are to be tested with the maximum and minimum size conductor. The mechanical sequence on any particular conductor size need not be repeated if it has been conducted as part of the static-heating sequence. If more than one conductor is secured by a single clamping means, additional sample sets may be necessary. See 11.3.

7 Preparation of Samples

7.1 General

7.1.1 To determine if a connector complies with the performance requirements, representative samples of the connector are to be assembled to conductors of the proper type, length, and size and in the manner that would be used in service. For the heat-cycling test, control-conductor assemblies are also to be prepared. These control-conductor assemblies are to be wired in series with the sample sets used for the heat-cycling test and are to carry the same test current. See 7.2.1 – 7.2.7, 7.4.2, 7.4.3 and 8.4.

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

7.1.3 If a connector is intended to be assembled to a conductor by means of more than one type of specific tool, the connector shall perform acceptably in the tests when any of the specific tools is employed in the assembly operation.

7.1.4 With reference to 7.1.3, in selecting tools for assembly of a connector to a conductor, the following features are to be considered:

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

b) Material of connector body;

c) Crimping die geometry;

d) The number of crimps; and

e) Similarity of crimp forces.

7.1.5 If specific instructions for assembling 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 used only if the connector is prefilled with the antioxidant. See 21.13 (d).

7.1.6 A tangless terminal connector – collar or meter-socket construction – shall be mounted for test purposes on a tang representative of the intended use, according to the manufacturer's assembly instructions and specifications for the tang material, plating, and cross-sectional dimensions. The length of the tang shall not exceed twice the length of the connector body. For the static-heating sequence, individual tangs with a mounting hole in the end opposite the connector are to be used. For the heat-cycling test, one tang with connectors mounted as illustrated in Figure 7.1 is to be used. If the specified mounting means includes auxiliary antirotation means, such means shall not increase the thermal mass or heat-radiating capabilities of the assembly.

Exception: A terminal connector built integral with a fuse clip, meter-socket jaw, or the like or intended for connection to a bus having a low conductivity because of material or cross-sectional area shall have the tang sized to prevent excessive heating of the tang. The test tang should not be so large that it operates cooler than the bodies of the connector as determined by thermocouples placed on the tangs and connector bodies.

Figure 7.1
Method for mounting tangless connectors

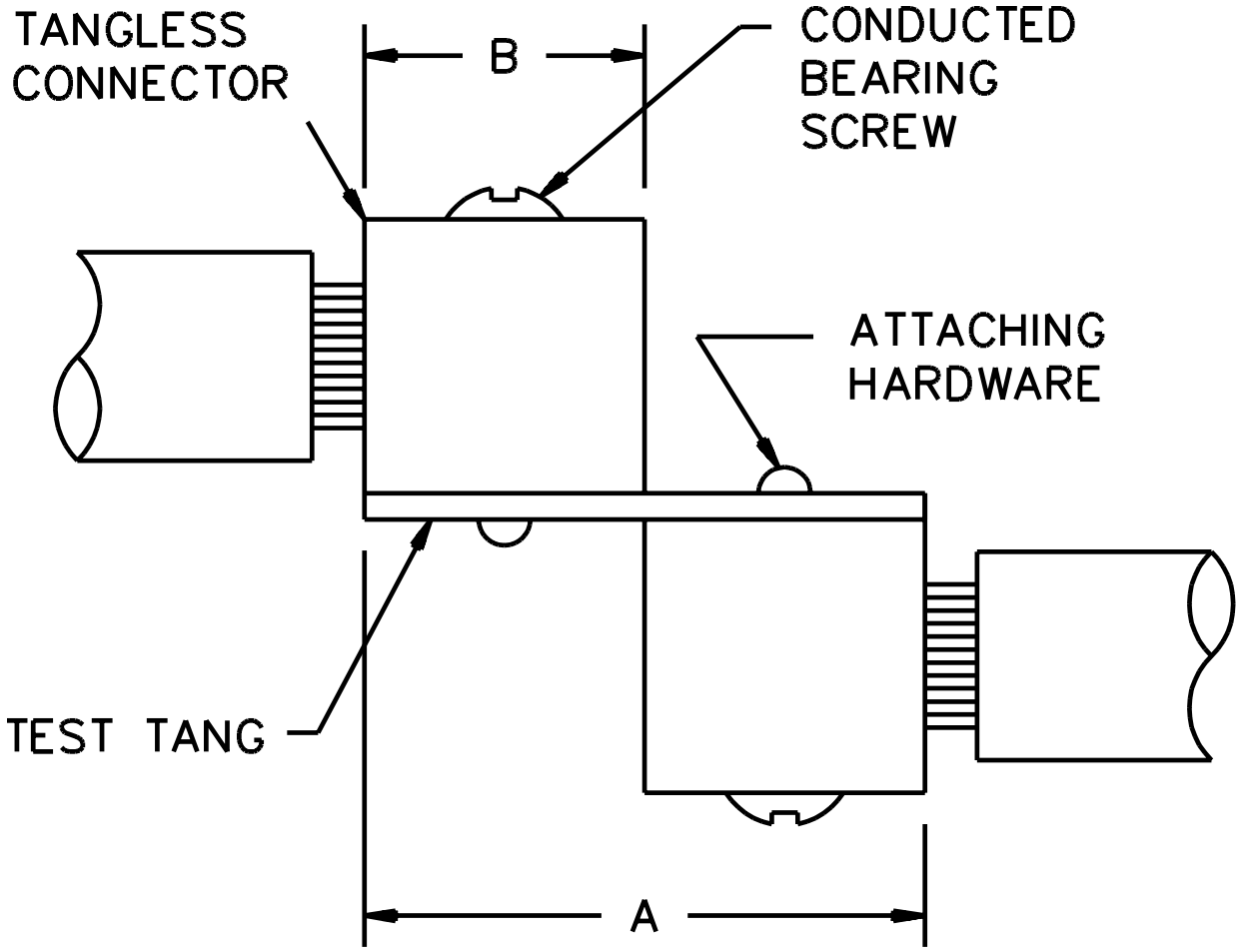

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Table 7.1
Conductor for test

Size of conductor to which connector is to be assembled AWG or kcmil (mm^2)		Number of strands, if stranded conductor		
		Copper		Aluminum
		Class B	Class C	Class B
24 – 30	(0.20 – 0.05)	a	–	–
22	(0.32)	7	–	–
20	(0.52)	10	–	–
18	(0.82)	16	–	–
16	(1.3)	26	–	–
14 – 2	(2.1 – 33.6)	7	19	7
1 – 4/0	(42.4 – 107.2)	19	37	19
250 – 500	(127 – 253)	37	61	37
600 – 1000	(304 – 508)	61	91	61
1250 – 1500	(635 – 759)	91	127	91
1750 – 2000	(886 – 1016)	127	271	127

[a] Number of strands may vary.

7.2 Test conductor

7.2.1 All test sample and control sample conductors shall be new – previously unused – and shall comply with the requirements in Table 7.1. See 6.1.10.

Exception: Conductors may be previously used:

a) With the concurrence of all parties concerned, and

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

Used conductor ends shall be cutoff and the resulting new ends of the conductor re-stripped in accordance with 7.3.1 – 7.3.4.

7.2.2 A connector may be acceptable for copper wire other than Class B or Class C stranding if the connector is subjected to all test sequences using the other stranding. See 21.7.

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

7.2.2.1 added May 22, 2000

7.2.3 With the concurrence of those concerned, the test sample and conductors used in the 500-cycle heat-cycling test for the evaluation of a 75°C rated connector may be used in the test to evaluate the connector for a 90°C rating at the required new test current and for an additional 500 cycles.

7.2.4 The insulation for copper conductors is to be black, Type 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.

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

7.2.5 The insulation for aluminum conductors is to be black, Type USE for all stranded sizes and Type THHN, THW, USE, or XHHW for solid No. 12 – 8 AWG (3.3 – 8.4 mm^2) conductors.

Exception: Insulation colored other than black may be used if 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 The test and the control conductors are to be as follows. See also 7.2.4, 7.2.5, and 7.2.6 and Table 7.1.

a) Aluminum:

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

2) Stranded – Nos. 12 – 3 AWG (3.3 – 26.7 mm^2), reverse lay concentric or compressed Class B, aluminum designation 1350H-19 (ASTM B230) or 1350H-16 or 1350H-26 (ASTM B609), and have an iron content of 0.4 percent maximum.

3) Stranded – No. 2 AWG – 1000 kcmil (33.6 – 508 mm^2):

i) Compact-stranded Class B, aluminum designation 1350H-19 (ASTM B230), and having an iron content of 0.25 percent maximum; or

ii) Reverse lay, compressed Class B, single-rated Type USE, aluminum designation 1350H-19 (ASTM B230) or 1350H-16 or 1350H-26 (ASTM B609), and having an iron content of 0.25 percent maximum. Type USE, RHH, or RHW using an AA-8000 series alloy conductor material is not to be used.

4) Stranded – larger than 1000 kcmil (508 mm^2) same as (1) above.

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 AWG – 2000 kcmil (2.1 – 1016 mm^2), soft annealed, and untinned. The stranding is to be concentric or compressed Class B or concentric Class C.

Exception: Connectors additionally rated for No. 2 AWG (33.6 mm^2) and larger compact-stranded copper conductors shall be tested with compact-stranded Class B copper conductors. See also 3.2 and 21.8.

c) Copper-clad aluminum:

1) Solid – No. 12 AWG (3.3 mm^2) and larger, fully annealed, and untinned.

2) Stranded – No. 12 AWG – 2000 kcmil (3.3 – 1016 mm^2), fully annealed, and untinned. The stranding is to be concentric Class B.

7.2.7 revised May 22, 2000

7.2.8 With reference to 7.2.7 (c) (1) and (2), ″fully annealed″ stock shall have a tensile strength of 18,500 ±3,500 psi or 128 ±24 kPa.

7.2.9 The length 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 7.2.

Table 7.2
Test conductor length

Conductor size,		Minimum[a] conductor length	
AWG or kcmil	(mm^2)	Inches	(mm)
30 – 8	(0.05 – 8.4)	8	(203)
6 – 3	(13.3 – 26.7)	12	(305)
2 – 500	(33.6 – 253)	18	(457)
Larger than 500	(253)	26	(660)

[a] The conductor length for the secureness test in the static-heating sequence is not to be less than that specified in 11.2 – 11.5.

7.2.10 The length of control conductors used in the heat-cycling tests is to be approximately twice the length of the test conductors used with the connector samples.

7.3 Conductor stripping

7.3.1 Conductors are to be stripped immediately prior to installation for a distance that is proper for insertion into the connector – see 7.3.2 – 7.3.4 – and are to be assembled in the connector in the intended manner. 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 but the conductor is not to be brushed or abraded.

7.3.2 For an insulated or uninsulated connector marked with a nominal strip length according to 21.13(c) and Table 21.1, the static-heating sequence tests and the heat-cycling tests are to be conducted with conductors stripped to the minimum tolerance specified in Table 7.3. The dielectric voltage-withstand test on an insulated connector is to be conducted with conductors stripped to the marked nominal strip length.

7.3.2 revised May 22, 2000

Table 7.3
Strip-length tolerances for conductors

Conductor size,		Tolerance,	
AWG or kcmil	(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 – 250	(8.4 – 127)	±1/16	(1.6)
300 – 2000	(152 – 1016)	±1/8	(3.2)

7.3.3 For an insulated connector marked with a maximum conductor strip length and a minimum conductor strip length according to 21.13(c) and Table 21.1, the static-heating sequence test and the heat-cycling test are to be conducted with conductors stripped to the minimum length specified by the manufacturer, and the dielectric voltage-withstand test is to be conducted with conductors stripped to the maximum length specified by the manufacturer. For an uninsulated connector marked with a minimum conductor strip length, the static-heating sequence test and the heat-cycling test are to be conducted with conductors stripped to the minimum length.

7.3.3 revised May 22, 2000

7.3.4 If the strip length is not marked on a connector, the insulation of the test conductor shall be stripped to allow the conductor to make contact with the full available length of the connector collar or barrel that contains the securing means. The conductor shall 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. If the conductor can project through the wire connector without interference, the conductor shall be installed to project a maximum of 1/4 inch (6.4 mm).

7.4 Tightening torque

7.4.1 The connection between the conductor and the connector is to be made before the start of the first test on any sample set. No additional tightening is to be done during the testing program.

7.4.2 A connector of the type described in 3.4 is to be mounted to a test bus according to the manufacturer's minimum specifications. During application of the tightening torque the connector assembly is to be free to turn about its mounting means except as restricted by the design of the connector or the specified mounting means. Subsequent turning of the connector about its mounting means is to be avoided except as may occur due to test procedures such as those for the secureness test. The mounting means is not to be retightened during the testing program. See 7.1.6.

7.4.3 The specified torque is to be applied by:

a) Tightening the fastening until the specified value of torque is attained; and

b) Maintaining this value, with a static torque reading, for 5 seconds.

7.4.4 The tightening torque values specified in Table 7.4, 7.5, or 7.6 apply to all connectors employing tightening nuts or bolts of the types described in the tables. The values in Table 7.4 are based on the size of the test conductor installed while the torque values specified in Tables 7.5 and 7.6 are independent of the test conductor installed, except that Table 7.5 is limited to use with connectors intended for No. 8 AWG (8.4 mm^2) or smaller conductors. If more than one conductor is secured by the same tightening means the torque value in Table 7.4 is to be applied based on the largest conductor installed. Samples prepared for the heat-cycling test shall be tightened using the values of torque shown in column A of Table 7.4, 7.5, or 7.6. All other tests shall have the samples prepared using the values in column B of the appropriate tables.

Exception: The manufacturer may assign a value of tightening torque considered appropriate for the design of the connector and according to the requirements for the product in which the connector is intended to be used. The static-heating sequence test and dielectric voltage-withstand test samples shall be prepared using this value of torque. The heat-cycling test samples shall be prepared using 90 percent of the manufacturer's assigned torque value. See 21.19 for marking requirements.

Table 7.4
Tightening torque for screws

Table 7.4 revised May 22, 2000

Test conductor size installed in connector,		Tightening torque, pound-inches (N·m)											
		Slotted head No. 10 and larger[a]						Hexagonal head – external drive socket wrench					
		Slot width – 0.047 inch (1.2 mm) or less and				Slot width – over 0.047 inch (1.2 mm) or							
		Slot length – 1/4 inch (6.4 mm) or less				Slot length – over 1/4 inch (6.4 mm)		Split-bolt connectors				Other connectors	
AWG or kcmil	(mm^2)	A		B		A		B		A		B		A		B	
30 – 10	(0.05 – 5.3)	15	(1.7)	20	(2.3)	25	(2.8)	35	(4.0)	65	(7.3)	80	(9.0)	60	(6.8)	75	(8.5)
8	(8.4)	20	(2.3)	25	(2.8)	30	(3.4)	40	(4.5)	65	(7.3)	80	(9.0)	60	(6.8)	75	(8.5)
6 – 4	(13.2 – 21.2)	25	(2.8)	35	(4.0)	35	(4.0)	45	(5.1)	135	(15.3)	165	(18.6)	90	(10.2)	110	(12.4)
3	(26.7)	25	(2.8)	35	(4.0)	40	(4.5)	50	(5.6)	225	(25.4)	275	(31.1)	125	(14.1)	150	(16.9)
2	(33.6)	30	(3.4)	40	(4.5)	40	(4.5)	50	(5.6)	225	(25.4)	275	(31.1)	125	(14.1)	150	(16.9)
1	(42.4)	–		–		40	(4.5)	50	(5.6)	225	(25.4)	275	(31.1)	125	(14.1)	150	(16.9)
1/0 – 2/0	(53.5 – 67.4)	–		–		40	(4.5)	50	(5.6)	315	(35.6)	385	(43.5)	150	(16.9)	180	(20.3)
3/0 – 4/0	(85.0 – 107.2)	–		–		40	(4.5)	50	(5.6)	400	(45.2)	500	(56.5)	200	(22.6)	250	(28.2)
250 – 350	(127 – 177)	–		–		40	(4.5)	50	(5.6)	550	(62.1)	650	(73.4)	250	(28.2)	325	(36.7)
400	(20.3)	–		–		40	(4.5)	50	(5.6)	675	(76.3)	825	(93.2)	250	(28.2)	325	(36.7)
500	(253)	–		–		40	(4.5)	50	(5.6)	675	(76.3)	825	(93.2)	300	(33.9)	375	(42.4)
600 – 750	(304 – 380)	–		–		40	(4.5)	50	(5.6)	800	(90.4)	1000	(113.0)	300	(33.9)	375	(42.4)
800 – 1000	(406 – 508)	–		–		40	(4.5)	50	(5.6)	900	(111.7)	1100	(124.3)	400	(45.2)	500	(56.5)
1250 – 2000	(635 – 1010)	–		–		–		–		900	(111.7)	1100	(124.3)	500	(56.5)	600	(67.8)

Note – Connectors having clamping screws with multiple tightening means (for example, a slotted, hexagonal head screw) are to be tested using both values of torque.

[a] For values of slot width or length not corresponding to those specified, select the largest torque value associated with the conductor size. Slot width is the nominal design value. Slot length is measured at the bottom of the slot.

Table 7.5
Tightening torque for slotted head screws smaller than No. 10 intended for use with No. 8 AWG or smaller conductors

Slot length of screw,		Tightening torque, pound-inches (N·m)			
		Slot width of screw smaller than 0.047 inch (1.2 mm)[b]		Slot width of screw 0.047 inch (1.2 mm) and larger[b]	
Inch	(mm)[a]	A	B	A	B
Less than 5/32	(4)	6 (0.68)	7 (0.79)	7 (0.79)	9 (1.0)
5/32	(4)	6 (0.68)	7 (0.79)	10 (1.1)	12 (1.4)
3/16	(4.8)	6 (0.68)	7 (0.79)	10 (1.1)	12 (1.4)
7/32	(5.6)	6 (0.68)	7 (0.79)	10 (1.1)	12 (1.4)
1/4	(6.4)	7 (0.79)	9 (1.0)	10 (1.1)	12 (1.4)
9/32	(7.1)			12 (1.4)	15 (1.7)
Above 9/32	(7.1)			16 (1.8)	20 (2.3)

[a] For slot lengths of intermediate values, select torques pertaining to next shorter slot lengths. Also, see note to Table 7.4 for screws with multiple tightening means. Slot length is measured at the bottom of the slot.
[b] Slot width is the nominal design value.

Table 7.6
Tightening torque for recessed allen head screws

Socket size across flats,		Tightening torque, pound-inches (N·m)			
Inch	(mm)[a]	A		B	
1/8	(3.2)	35	(4.0)	45	(5.1)
5/32	(4.0)	80	(9.0)	100	(11.3)
3/16	(4.8)	100	(11.3)	120	(13.6)
7/32	(5.6)	120	(13.6)	150	(16.9)
1/4	(6.4)	150	(16.9)	200	(22.6)
5/16	(7.9)	225	(25.4)	275	(31.1)
3/8	(9.5)	300	(33.9)	375	(42.4)
1/2	(12.7)	400	(45.2)	500	(56.5)
9/16	(14.3)	500	(56.5)	600	(67.8)

[a] See note to Table 7.4 for screws with multiple tightening means.

7.5 Equalizer

7.5.1 For the heat-cycling test each stranded control conductor and each stranded conductor that has been terminated or is intended to be terminated in a test connector is to have the free end welded or brazed to an equalizer to make a thorough electrical connection for each strand. For a connector intended for paralleling conductors, the number of control conductors shall be equal to the number of conductors being tested. An equalizer is not required but may be used for a solid test conductor.

Exception: For other than control conductors, tool applied compression connectors without welding may be used if acceptable to the manufacturer.

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, or

b) A tool applied compression connector or 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 connector is to be welded into a homogeneous mass with the bus or connector. For a connector intended for paralleling conductors, the hole pattern spacing in the equalizer is to be identical to the hole spacing pattern in the connector. 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 applicable bus size indicated in Table 7.7. For test currents over 2000 amperes, the size of the equalizer is to be based on 1000 amperes per square inch (155 A/cm^2) of cross section for a copper bus equalizer and 750 amperes per square inch (116 A/cm^2) of cross section for aluminum bus equalizers.

Table 7.7
Equalizer dimensions

Range of test current, amperes	Maximum cross-section, inches[a]	
	Copper	Aluminum
0 – 50	1/8 × 1/2	1/8 × 1/2
51 – 125	1/8 × 1	1/8 × 1 - 1/4
126 – 225	1/8 × 1 - 7/8	1/8 × 2 - 1/4
226 – 400	1/4 × 1 - 1/2	1/4 × 2
401 – 600	1/4 × 2	1/4 × 3
601 – 800	1/4 × 3	1/4 × 4
801 – 1000	1/4 × 4	3/8 × 3 - 1/2
1001 – 1400	1/2 × 3 or two 1/4 × 3	1/2 × 3 - 1/2
1401 – 2000	1/2 × 4 or two 1/4 × 4	1/2 × 5
2001 – 3000	1 × 3	3/4 × 5
3000 – 4000	1 × 4	1 × 5 - 1/2
4000 – 4800	1 - 1/4 × 4	2 × 4

[a] For SI units 1 inch = 25.4 mm.

7.5.3 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. Connectors of the same type as those under test or of a type that makes as reliable an electrical connection as is possible shall be used.

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 (0.05 mm^2).

8.2 When thermocouples are used in determining 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.

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 listed in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1-1982.

8.3 revised May 22, 2000

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 soldering, by use of an adhesive, or by other equivalent means that will permit the replacement of the conductor insulation over the thermocouple location and that will not require penetration of the surface of the conductor metal; for example, drilling and peening is not acceptable.

8.5 A thermocouple is to be located on each control conductor. For control conductors used when testing a connector intended for paralleling conductors, the thermocouples are to be the same length and connected in parallel to determine the average control conductor temperature.

8.6 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 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.

8.7 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) One conductor strand is to be pried out of the stranding just enough to permit inserting 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 approximately 1/8 inch (3.2 mm) as illustrated in Figure 8.1. The conductor strand is then lightly tapped back down on the copper ribbon.

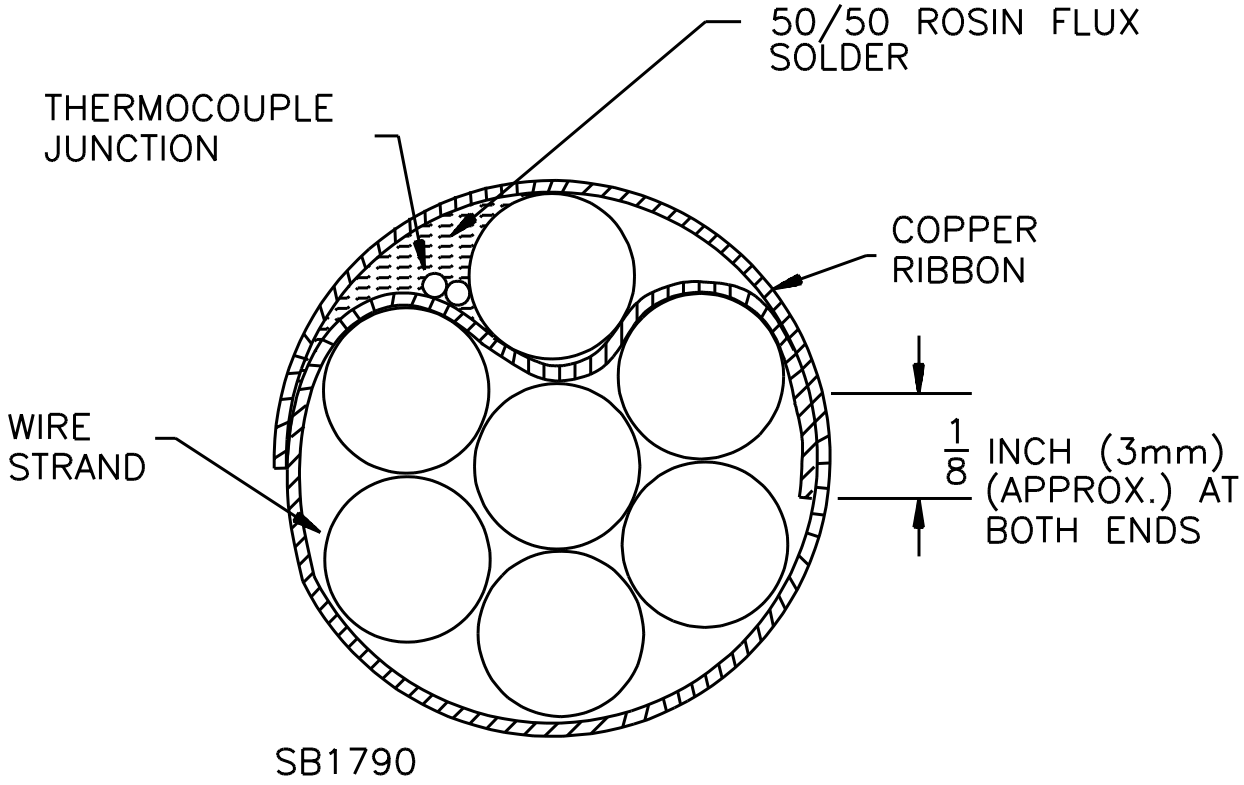
c) The copper ribbon is to be wrapped partially around the conductor strands back to the one strand that has been pried out.

d) 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.

e) 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 may be used to hold it in place.

Exception: The technique specified in 8.6 may be used if the thermocouple is secured by an adhesive.

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



8.8 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 thermocouples into small holes drilled in the connector or by the use of small quantities of an adhesive.

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; if 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 the exception to 9.2.5, 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. If all thermocouples employed are the same length, they may 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 heat-cycling test – see 9.1.2 and 9.1.5 – 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 three readings indicating stable temperature was recorded.

9 Heat-Cycling Test

9.1 General

9.1.1 Samples are to be selected and prepared as described in Sections 6 and 7. The test assembly and securing hardware are to be as described in 9.2.1 – 9.3.2. Connectors intended for use with snap-on molded insulating covers or packaged with insulating materials that are intended to be wrapped around the completed connector/conductor termination are to be tested without the insulating covers or material installed. The sample sets shall complete 500 cycles of equal current-on and current-off operations for the periods of time specified in Table 9.1, other than as noted in 9.1.2, while carrying the current specified for the connector temperature rating and conductor size being tested. Temperatures are to be measured and recorded for at least 1 cycle of each working day. The heat-cycling test shall be completed without any connector exceeding a 125°C (225°F) temperature rise above the ambient temperature for any recorded cycle. The stability factor ″Si″ – see 9.1.3 – determined for each of the 11 connector temperature measurements taken at approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles shall not exceed ±10.

9.1.2 For a connector intended for paralleling conductors, the on time is to be the time it takes for the connector to reach stable temperatures; the off time is to be the time it takes to reach room temperature. This cycle time is to be determined in the first 25 cycles of operation. See 8.11.

Table 9.1
Test current for 75° and 90°C connectors intended for a single conductor, amperes

Table 9.1 effective June 25, 1997

Conductor size, AWG or kcmil (mm^2)		Copper				Aluminum and Copper-Clad Aluminum				
		Assigned maximum ampere rating[b]	Static heating[a,c,g]	Heat cycling connector temperature rating[a]		Assigned maximum ampere rating[b]	Static heating[a,c,g]	Heat cycling connector temperature rating[a]		On (and off) times for heat cycling hours[f]
				75°C[d,g]	90°C[e,g]			75°C[d,g]	90°C[e,g]	
30	(0.05)	–	3	3.5	4	–	–	–	–	1
28	(0.08)	–	3.5	4	5	–	–	–	–	1
26	(0.13)	–	5.5	6	8	–	–	–	–	1
24	(0.20)	–	7	8	10	–	–	–	–	1
22	(0.32)	–	9	12	13	–	–	–	–	1
20	(0.52)	–	12	16	17	–	–	–	–	1
18	(0.823)	–	17	19	24	–	–	–	–	1
16	(1.31)	–	18	20	31	–	–	–	–	1
14	(2.08)	15	[20] 30	[22] 33	[27] 40	–	–	–	–	1
12	(3.31)	20	[25] 35	[28] 39	[40] 54	15	[20] 30	[22] 33	[29] 43	1
10	(5.261)	30	[40] 50	[45] 56	[60] 75	25	[30] 40	[34] 45	[46] 60	1
8	(8.367)	50	70	80	100	40	55	60	77	1
6	(13.30)	65	95	105	131	50	75	85	102	1
4	(21.15)	85	125	140	175	65	100	110	140	1
3	(26.67)	100	145	165	205	75	115	125	160	1
2	(33.62)	115	170	190	240	90	135	150	190	1
1	(42.41)	130	195	220	275	100	155	175	215	1
1/0	(53.49)	150	230	255	320	120	180	200	250	1
2/0	(67.43)	175	265	300	370	135	210	230	295	1
3/0	(85.01)	200	310	345	435	155	240	270	335	1
4/0	(107)	230	360	405	505	180	280	315	390	1-1/2
250	(127)	255	405	445	565	205	315	350	440	1-1/2
300	(152)	285	445	500	625	230	350	390	490	1-1/2
350	(177)	310	505	555	705	250	395	435	555	1-1/2
400	(203)	335	545	605	765	270	425	470	595	1-1/2
500	(253)	380	620	690	870	310	485	540	680	2
600	(304)	420	690	775	965	340	540	600	760	2
700	(355)	460	755	850	1055	375	595	675	835	2
750	(380)	475	785	885	1100	385	620	700	870	2
800	(405)	490	815	920	1140	395	645	725	905	2
900	(456)	520	870	980	1220	425	700	785	980	2
1000	(507)	545	935	1045	1310	445	750	840	1050	2
1250	(633)	590	1065	1185	1490	485	855	950	1195	3
1500	(760)	625	1175	1320	1645	520	950	1065	1330	3
1750	(887)	650	1280	1435	1790	545	1050	1175	1470	3
2000	(1010)	665	1385	1540	1940	560	1150	1280	1610	3

[a] See 6.2.1, 6.2.2, and 9.1.1.

[b] Values are for 75°C, not more than three conductors in raceway or cable ampacities, National Electrical Code, ANSI/NFPA 70-1996, except that for Nos. 14 – 10 AWG copper conductor and Nos. 12 – 10 AWG aluminum conductor, the values are load-current ratings.

[c] Values are for 75°C single conductor in free air ampacities, National Electrical Code, ANSI/NFPA 70-1996.

[d] Values are approximately 112 percent of the static-heating test currents.

[e] Values for No. 8 AWG and larger conductors are approximately 140 percent of the static-heating test current.

[f] See 9.1.5.

[g] Values in brackets apply to connectors with assigned ampere ratings.

Table 9.2
Cycling test currents for 75°C and 90°C intended for paralleling conductors, amperes

Table 9.2 revised May 22, 2000

Conductor size, AWG or kcmil	Number and material of conductors											
	Two				Three				Four			
	Copper		Aluminum		Copper		Aluminum		Copper		Aluminum	
	75°C	90°C	75°C	90°C	75°C	90°C	75°C	90°C	75°C	90°C	75°C	90°C
1/0	336	420	269	336	504	630	403	504	538	672	431	538
2/0	392	490	302	378	588	735	454	567	628	784	484	605
3/0	448	560	347	434	672	840	521	651	717	896	556	695
4/0	515	644	403	504	773	966	605	756	824	1030	645	806
250	590	738	460	574	885	1106	689	861	1180	1476	920	1148
300	649	811	510	637	972	1215	765	956	1298	1622	1020	1274
350	736	920	576	720	1103	1379	862	1078	1472	1840	1132	1440
400	794	993	620	774	1191	1488	928	1161	1588	1986	1240	1548
500	903	1129	707	883	1354	1693	1060	1324	1806	2258	1414	1766
600	1160	1450	907	1145	1740	2176	1361	1718	2320	2900	1815	2290
700	1269	1587	1000	1250	1903	2379	1500	1875	2538	3174	2000	2500
750	1320	1650	1041	1302	1979	2474	1562	1953	2640	3300	2082	2604
800	1370	1713	1084	1355	2054	2568	1626	2033	2740	3426	2168	2710
900	1462	1828	1176	1470	2193	2741	1764	2205	2924	3656	2352	2940
1000	1572	1965	1260	1575	2356	2946	1891	2363	3144	3930	2520	3150
1250	1790	2238	1437	1796	2684	3356	2155	2694	3580	4476	2874	3592
1500	1975	2469	1596	1995	2961	3701	2395	2993	3950	4938	3192	3990
1750	2150	2688	1764	2205	3226	4032	2647	3308	4300	5376	3528	4410
2000	2328	2910	1932	2415	3491	4364	2899	3623	4656	5820	3864	4830

Table 9.3
Static test currents for 75°C and 90°C connectors intended for paralleling conductors, amperes

Conductor sizes, AWG or kcmil	Number and material of conductors					
	Two		Three		Four	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum
1/0	300	240	450	360	480	384
2/0	350	270	525	405	560	432
3/0	400	310	600	465	640	496
4/0	460	360	690	540	736	576
250	527	410	790	615	1053	820
300	579	455	868	683	1158	910
350	657	514	985	770	1314	1028
400	709	553	1063	829	1418	1106
500	806	631	1209	946	1612	1262
600	1035	810	1554	1215	2070	1620
700	1133	893	1699	1339	2266	1786
750	1178	930	1767	1395	2356	1860
800	1223	968	1834	1452	2446	1936
900	1305	1050	1958	1575	2610	2100
1000	1403	1125	2104	1688	2806	2250
1250	1598	1383	2397	1924	3196	2566
1500	1763	1425	2644	2138	3526	2850
1750	1920	1575	2880	2363	3840	3150
2000	2078	1725	3117	2588	4156	3450

Note –

1) The currents for conductor sizes 1/0 – 4/0 AWG are based on the National Electrical Code (NEC), NFPA 70 - 1996, Table 310-16, 75°C column, multiplied by the number of conductors and de-rated by 80 percent.

2) The currents for conductor sizes 250 kcmil and larger are in accordance with the NEC, NFPA 70 - 1996, Sections 318-11(b) (1) and 318-11(b) (2) for Table 310-17 (free air ampacities), 75°C column, multiplied by the number of conductors and de-rated as follows:

250 – 500 kcmil – de-rated by 65 percent

600 kcmil and larger – de-rated by 75 percent

3) Any number of conductors other than tabulated are to be de-rated in accordance with the NEC, NFPA 70 – 1996, Table 310-16, Note 8.

9.1.3 The stability factor "S_i" for each of the 11 temperature measurements mentioned in 9.1 is to be determined by applying the following equations:

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

$$S_i = d_i - D$$

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 °C			
Cycle number	Connector	Control conductor	d	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	

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

9.1.5 The current-off times specified in Table 9.1 may 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 may be employed to reduce the current-off time with the concurrence of those concerned. See 8.11.

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. Tang-type connectors are to be bolted back-to-back and equalizers are to be bolted together or to lengths of bus using the hardware specified in 9.3.1.

9.2.2 For a connector intended for paralleling conductors, the initial currents through the conductors are to be balanced so that the highest current in a conductor is not more than 125 percent of the current in any parallel conductor.

Exception: Current balance need not be attained if agreeable to those concerned.

9.2.3 Bus-bar lengths mentioned in 9.2.1 are to be the minimum necessary to provide sufficient contact area for the equalizers while maintaining the center-to-center sample spacings specified in 9.2.4. 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 amp/cm^2) for copper or 800 amperes per square inch (124 amp/cm^2) for copper-clad aluminum or aluminum bus.

Exception: Bus sizes for 226 – 400 amperes and 401 – 600 amperes specified in Table 7.7 are acceptable.

9.2.4 Individual connector/conductor samples are to be separated by at least 18 inches (457 mm) when measured center-to-center.

Exception No. 1: The spacing may be reduced with the concurrence of those concerned.

Exception No. 2: The spacing may be reduced to a minimum of 6 inches (152 mm) if a thermal barrier is used between assemblies. The thermal barrier is to extend at least 6 inches in a vertical direction and 1 inch (25.4 mm) in a horizontal direction beyond the extremities of the connector.

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

Exception: The spacing need not be maintained if a solid 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.

9.2.6 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 reduce the likelihood of disturbing test connections during handling of the samples and to reduce 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.

9.2.7 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.

9.3 Parts for securement

9.3.1 The following hardware is to be used to make the connections mentioned in 9.2.1. Once the initial assembly is completed, there is to be no subsequent retightening.

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

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

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

d) Clean, dry, nonlubricated screws and bolts and nuts are to be used. The assembled hardware shall be torqued to the following values:

Screw or bolt size	Tightening torque	
	Pound-feet (N·m)	
No. 8 or smaller	1.5	(2)
No. 10	2.0	(3)
1/4 inch	6	(8)
5/16 inch	11	(15)
3/8 inch	19	(26)
7/16 inch	30	(41)
1/2 inch	40	(54)
9/16, 5/8 inch, or larger	55	(75)

Exception No. 1: If the manufacturer's installation instructions – see 9.3.2 – specify that a dished washer is to be used, the hardware is to be as follows:

a) One plated or stainless steel dished washer per securing bolt is to be used;

b) Bolts or nuts are to be tightened until the crown of the washer is no longer discernible;

c) A flat washer as mentioned in 9.3.1 (b) is to be used on the side of the tang-to-tang or tang-to-bus connection opposite the dished washer; and

d) The design of the dished washer is to be such that the force needed to flatten the washer is as specified for the corresponding bolt size in the following table:

Bolt diameter,	Force, minimum	
Inch	Pounds	(N)
1/4	800	(3560)
5/16	1000	(4450)
3/8	1400	(6230)
7/16, 1/2	2700	(12015)
9/16, 5/8, or larger	3400	(15130)

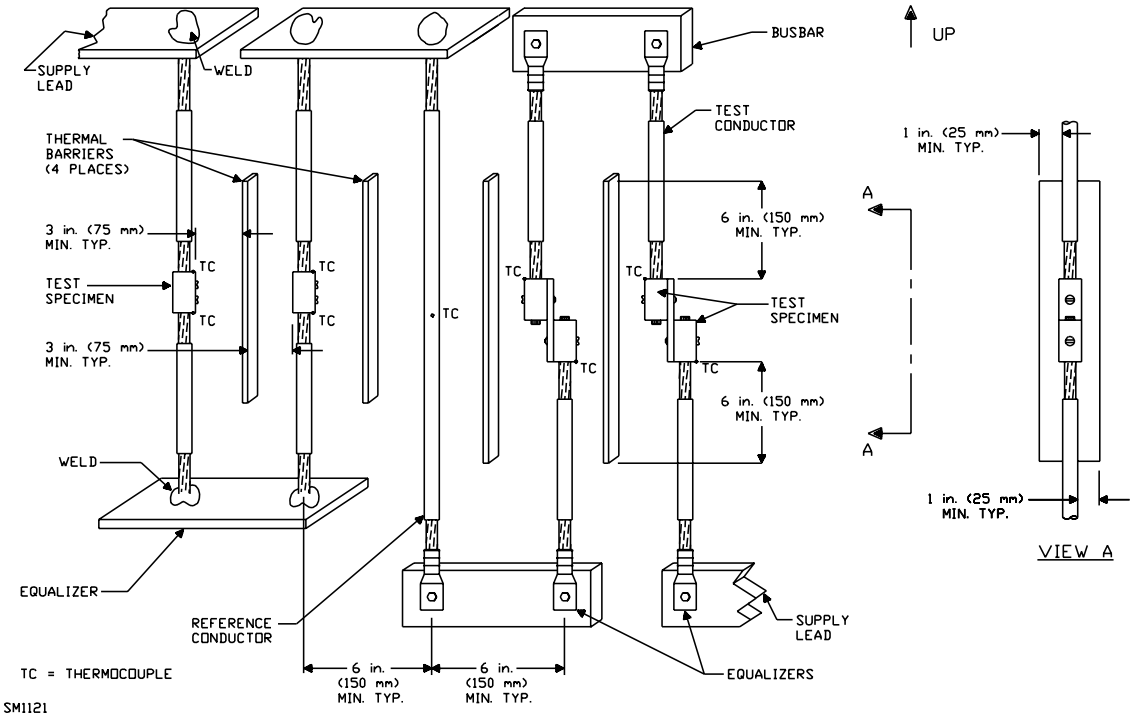
Exception No. 2: Tests on a connector may be conducted using:

a) Hardware other than mentioned,

b) Part securement torque values, or

c) Dished or other washers having different characteristics if the manufacturer's installation instructions – see 9.3.2 – specify all necessary hardware.

Figure 9.1
Vertical arrangement of sample for heat-cycling test



9.3.2 For a tangless connector, the following information shall be provided:

a) Material of tang;

b) Plating on tang;

c) Minimum cross-section of tang;

d) Material of mounting screw;

e) Use of a washer, type and size; and

f) Torque to be used to secure the connector to the tang.

10 Static-Heating Test

10.1 Samples are to be selected and prepared as described in Sections 6 and 7 except that equalizers are not to be used. See 7.5.3.

10.2 The test assembly and securing hardware are to be as described for the heat-cycling test in 9.2.1 – 9.3.2.

10.3 The sample sets shall continuously carry the test current specified in Table 9.1 or 9.3 for the conductor size tested until stable temperatures are reached – see 8.11 – without exceeding a 50°C (90°F) temperature rise above ambient temperature.

Exception No. 1: See exception to 6.3.1.

Exception No. 2: The temperature rise on an ampere-rated connector may exceed 50°C provided that when the connector is used in the intended equipment application, the temperature rise on the connector does not exceed the maximum temperature rise permitted in the end-use application or the temperature rating of the connector.

11 Secureness Test

11.1 The joint between a connector and the conductor of a sample set shall be intact after being subjected to the test described in 11.2 – 11.5 for 30 minutes. For the secureness tests on a connector intended for paralleling conductors, the tests are to be conducted on only one conductor entry hole if all conductor entry holes are identical in construction.

Exception: Nos. 30 – 20 AWG (0.05 – 0.52 mm ^{2}) conductors are not subjected to the secureness test.

11.2 A terminal connector is to be fastened to a length of conductor not less than 3 inches (76.2 mm) longer than the height specified in Table 11.1, and is to be rigidly secured in a vertical position simulating actual service conditions. 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 at a rate of approximately 9 rpm and in such a manner that the center of the bushing describes a circle in a horizontal plane – see Figure 11.1. 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 so there is no 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.

Table 11.1
Test values

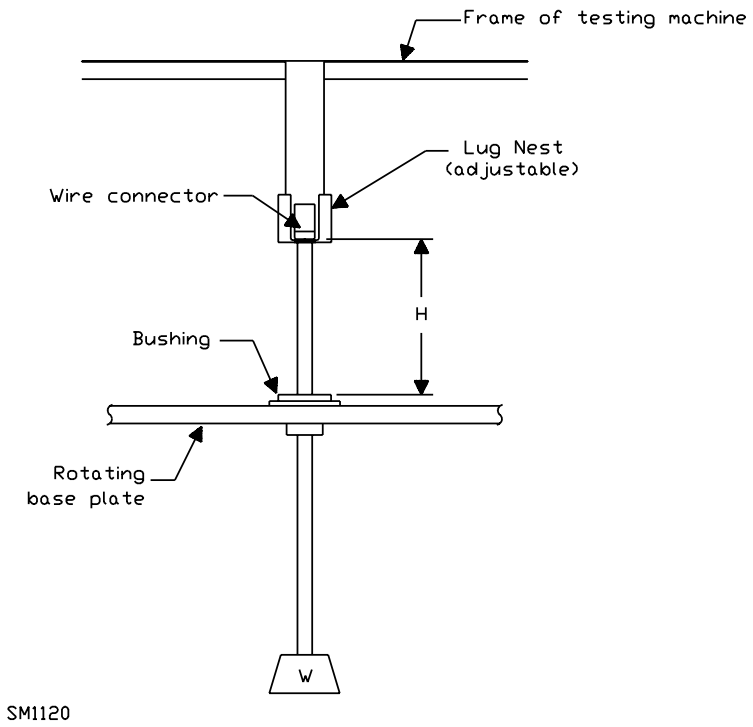
Size of conductor, AWG or kcmil (mm^2)		Diameter of bushing hole, inches[a,c]	Height, inches[b,c]	Weight, pounds[c]	
				Copper	Aluminum or copper-clad aluminum
18	(0.82)	1/4	10-1/4	2	–
16	(1.3)	1/4	10-1/4	2	–
14	(2.1)	3/8	11	3	–
12	(3.3)	3/8	11	5	1.5
10	(5.3)	3/8	11	5	1.5
8	(8.4)	3/8	11	8	3
6	(13.3)	1/2	11-3/4	18	10
4	(21.2)	1/2	11-3/4	30	15
3	(26.7)	9/16	12-1/2	30	15
2	(33.6)	9/16	12-1/2	30	15
1	(42.4)	5/8	13-1/2	50	25
1/0	(53.5)	5/8	13-1/2	50	25
2/0	(67.4)	3/4	14-1/2	50	25
3/0	(85.0)	3/4	14-1/2	60	30
4/0	(107)	3/4	14-1/2	60	30
250	(127)	7/8	16	60	30
300	(156)	7/8	16	80	40
350	(177)	1	17	80	40
400	(203)	1	17	80	40
500	(253)	1-1/8	18-1/4	100	50
600	(304)	1-1/8	18-1/4	100	50
700	(354)	1-1/4	19-1/2	100	50
750	(380)	1-1/4	19-1/2	110	55
800	(406)	1-3/8	21-1/4	110	55
900	(456)	1-3/8	21-1/4	110	55
1000	(508)	1-1/2	22-1/4	110	55
1250	(635)	1-3/4	26	155	75
1500	(759)	2	28	180	90
1750	(886)	2-1/8	30	205	100
2000	(1010)	2-1/8	30	240	120

[a] If a hole with the diameter given is not adequate to accommodate the conductor without binding, a bushing having a hole of slightly large diameter may be used.

[b] For Nos. 12 – 4 AWG aluminum conductor, use 12-1/2 inches.

[c] For SI units 1 inch = 25.4 mm and 1 pound = 454 grams.

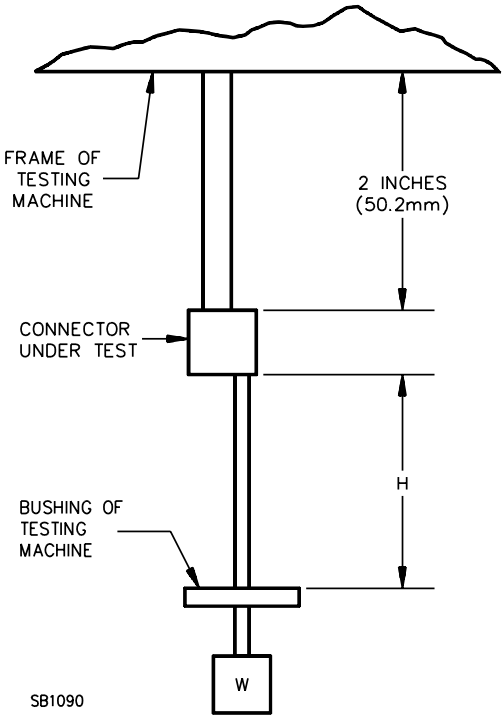
Figure 11.1
Secureness test setup



11.3 If a wire connector is intended to secure more than one conductor at a time by a single clamping means, only one conductor in each combination is to be tested for secureness. If the conductors in the combination are of different sizes, separate sample sets are to be used for testing each size of conductor.

11.4 For the test of a splicing connector in which the conductors lie parallel to or in line with each other, the set-up is to be as illustrated in Figure 11.2. If 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 selected from Table 11.1 according to 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 employed for attaching the weight and for securing the assembly to the frame of the testing machine. The testing machine is to be operated as described in 11.2.

Figure 11.2
Splicing connector test arrangement



11.5 A splicing connector in which the conductors do not lie parallel to or in line with each other is to be assembled to a length of through conductor and a length of tap conductor, each of the size for which the connector is intended. The assembly 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 (50.8 mm) from the ends of the connector. The depth of the yoke is to be approximately 3 inches (76.2 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 not less than 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 11.2.

12 Repeated Static-Heating Test

12.1 The sample sets previously subjected to the static-heating test and the secureness test shall 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.

Exception: A connector designed for paralleling conductors need not be subjected to this test.

13 Pullout Test

13.1 The connectors subjected to the repeated static-heating test or secureness test shall be subjected to a direct pull of the applicable value specified in Table 13.1 for 1 minute. For a connector intended to secure more than one conductor at a time by a single clamping means, only those conductors that have been subjected to the secureness test in accordance with 11.3 are to be subjected to the pullout test. In accordance with the Exception to 5.1 and 11.1, Nos. 30 – 20 AWG (0.05 – 0.52 mm^2) need not be subjected to the secureness test prior to the pullout test. The connector is not acceptable if it becomes separated from the conductor or conductors as a result of the test.

13.2 For an insulated connector in which the insulation is assembled to the connector during installation, the test is to be conducted with the insulation in place if it is always supplied with the connector by the manufacturer. Otherwise the test is to be made without the insulation assembled to the connector. 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 will be no sudden application of force or jerking during the test. See Secureness Test, Section 11.

Table 13.1
Test values for connectors

Table 13.1 revised May 22, 2000

Size of conductor, AWG or kcmil (mm^2)		Pullout force, pounds (N)			
		Copper		Aluminum or copper-clad aluminum	
30	(0.05)	1-1/2		–	
28	(0.08)	2		–	
26	(0.13)	3		–	
24	(0.20)	5		–	
22	(0.32)	8	(35.6)	–	
20	(0.52)	13	(57.9)	–	
18	(0.82)	20	(89.0)	–	
16	(1.3)	30	(133.5)	–	
14	(2.1)	50	(222.5)	–	
12	(3.3)	70	(311.5)	35	(155.8)
10	(5.3)	80	(356.0)	40	(178.0)
8	(8.4)	90	(400.5)	45	(200.3)
6	(13.3)	100	(445.0)	50	(222.5)
4	(21.2)	140	(623.0)	70	(311.5)
3	(26.7)	160	(712.0)	80	(356.0)
2	(33.6)	180	(801.0)	90	(400.5)
1	(42.4)	200	(890.0)	100	(445.0)
1/0	(53.5)	250	(1112.5)	125	(556.3)
2/0	(67.4)	300	(1235.0)	150	(667.5)
3/0	(85.0)	350	(1557.5)	175	(778.8)
4/0	(107)	450	(2002.5)	225	(1001.3)
250	(127)	500	(2225.0)	250	(1112.5)
300	(156)	550	(2447.5)	275	(1223.8)
350	(177)	600	(2670.0)	300	(1335.0)
400	(203)	650	(2892.5)	325	(1446.3)
500	(253)	800	(3560.0)	400	(1780.0)
600	(304)	900	(4005.0)	450	(2002.5)
700 – 2000	(354 – 1010)	1000	(4450.0)	500	(2225.0)

14 Dielectric Voltage-Withstand Test

14.1 General

14.1.1 No sample is to be subjected to more than one dielectric voltage-withstand test.

Exception: If 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.

14.1.2 For a connector intended to secure combinations of conductors of different total cross-sectional area, or single conductors of different AWG sizes, 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, if only one conductor is intended to be secured; 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 if only one wire is intended to be secured.

14.1.3 A connector is unacceptable if any sample performs unacceptably in any specified test.

14.1.4 An insulated wire connector shall withstand the dielectric voltage-withstand tests indicated in Table 14.1.

Table 14.1
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 and intended for use with:	
	(1) No. 10 AWG (5.3 mm^2) or smaller conductors	A, C
	(2) Nos. 8 – 4/0 AWG (8.4 – 107.2 mm^2) conductors	A
II.	Insulated connectors not covered in Item 1.	A, B

[a] A – Test A is described in 14.2.1 – 14.2.3 and Tables 14.2 and 14.3.
B – Test B is described in 14.3.1 and Table 14.4.
C – Test C is described in 14.4.1.

Table 14.2
Required tests and samples

Table 14.2 revised May 22, 2000

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 conductor before such conditioning[b]	6
Test after oven conditioning, with samples assembled to conductors after such conditioning[c]	6

[a] See 14.1.2.
[b] See 14.2.2 and Table 14.3.
[c] See 14.2.3.

Table 14.3
Oven-conditioning specifications

Rated temperature of connector		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

Table 14.4
Test voltage

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

14.2 Test A, insulation puncture

14.2.1 The tests to be conducted and the number of samples for each test are to be as specified in Table 14.2. 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 signs and lighting 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 that 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, may 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 would allow the entrance of shot, thereby possibly resulting in flashover, is to have those openings closed with tape, petrolatum, epoxy, silicone, rubber, or other acceptable material; and the exposed tang of a terminal connector is to be similarly treated. 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 acceptable. If 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.

Exception: A smaller than No. 7-1/2 (higher size number) shot may be used with concurrence of those concerned.

14.2.2 With reference to note b to Table 14.2, samples previously assembled to conductors are to be conditioned in an air-circulating oven, according to Table 14.3.

14.2.3 With reference to note c of Table 14.2, the samples not previously assembled 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 the wires pre-installed, but not crimped, prior to the oven aging. The samples are then to be allowed to cool to room temperature. Nylon samples are then to be conditioned for 24 hours at a relative humidity of 85 ±5 percent at 30 ±2°C (86 ±4°F). The samples are then to be assembled (or crimped) to conductors in the intended manner.

14.3 Test B, flashover

14.3.1 Six samples are to be tested in the as-received condition. See 14.1.2. Each sample is to be wired as intended. The 1-minute value of test potential specified in Table 14.4 is to be applied for that interval, and the potential is then to be rapidly and steadily increased to some value higher than the maximum value specified in Table 14.4 – but breakdown at a value higher than the specified maximum is not unacceptable – and is to be immediately removed. 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 in No. 7-1/2 conductive shot that 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. To reduce the likelihood of flashover to the exposed tang of a terminal connector or the likelihood of insulation puncture, the outer surface of the connector insulation and the exposed tang may be supplemented with tape, petrolatum, epoxy, silicone, rubber, or other acceptable insulating material so that it does not interfere with the position of the outer electrode immediately adjacent to the conductor opening. If flashover form 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 acceptable.

Exception No. 1: At the manufacturer's option, after being held at the required test potential for 1 minute, the potential may be reduced to 0 volts and then rapidly and steadily increased to the higher potential.

Exception No. 2: A smaller than No. 7-1/2 (higher size number) shot may be used with concurrence of those concerned.

14.4 Test C, flashover

14.4.1 Six samples are to be tested in the as received condition. See 14.1.2. The test potential is to be 1600 volts for a connector rated 300 volts, 3000 volts for a connector rated 600 volts – 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 acceptable.

15 Secureness-of-Insulation Test

15.1 For other than a connector as described in 15.2, 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 (89.0 N) for a connector employing a No. 30 – 18 AWG (0.05 – 0.84 mm^2) conductor, or 30 pounds (133.5 N) for any other connector, is applied for 1 minute between the insulation and the connector.

15.2 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 15.3.

15.3 The test mentioned in 15.2 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 according to Table 14.3, and

b) A 5-pound (22.3-N) pull on an assembled as-received sample, on a sample that has been assembled to a conductor before oven conditioning according to Table 14.3, and on a sample that has been assembled to the conductor after oven conditioning at 100°C (212°F) according to 14.2.3.

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

15.4 With reference to the requirements in 15.1 and 15.2, a temporary distortion of flexible insulating material during the test is considered acceptable. Tearing or breaking of the insulation is acceptable if the results of a repeated dielectric voltage-withstand test are acceptable.

The variety of designs of connectors is such that it is not practicable to specify in detail how the pull is to be applied; the arrangement is to be such that the tendency for the insulation to be damaged or to be separated from the body is greatest.

15.5 A connector having flexible insulation that is assembled to the body of the connector after the latter is assembled to a conductor or conductors is not to be subjected to the test mentioned in 15.1 until after the insulation has regained its normal shape after being assembled to the connector.

16 Drop Test

16.1 A latch or a lock employed on the cover of an insulated splicing connector intended for use with a No. 2 AWG (33.6 mm^2) or larger conductor shall not open or break when the connector is subjected to the drop test described in 16.2.

16.2 The drop test is to consist of dropping the insulation covers and connectors onto a maple board from a height of 3 feet (914 mm). Six samples are to be assembled with the combination of conductors of the smallest total cross-sectional area for which the connector is intended; and six samples are to be assembled with the combination of conductors of the largest total cross-sectional area. The connectors are to be assembled so that 3 inches (76.2 mm) of the conductor extends from the ends of the insulating cover. The test is to be conducted on insulating covers that have been oven-conditioned according to Table 14.3, on as-received samples, and on samples that have been subjected to minus 10°C (14°F) for 2 hours. The assemblies that have been subjected to minus 10°C for 2 hours are to be subjected to the drop test as soon as possible after removal from the cold box. Each assembly is to be dropped four times so that an impact occurs at the top, bottom, sides, and edges except that the samples subjected to minus 10°C are to be dropped only once so that the point of impact is that judged to be the most severe from observation of the drop test on the as received and oven-conditioned samples. Cracks are acceptable if the assemblies successfully comply with the requirement in Dielectric Voltage-Withstand After Drop Test, Section 17.

17 Dielectric Voltage-Withstand After Drop Test

17.1 An insulating splicing connector that has been subjected to the drop test described in 16.1 and 16.2 shall comply with the dielectric voltage-withstand requirements described in Dielectric Voltage-Withstand Test, Section 14. Breakdown through a crack is considered equivalent to insulation puncture.

18 Flexing Test

18.1 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 18.2.

18.2 The flexing test is to be conducted on insulating covers in the as received condition, after oven conditioning according to Table 14.3 and after conditioning at minus 10°C (14°F) for 2 hours. The samples conditioned at minus 10°C are to be allowed 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 prepared as described in 16.2 except that only conductor of the maximum cross-sectional area is to be used. The insulating cover is to be completely opened and closed 20 times. If flexible extensions are provided around the cables, the cables are also to be flexed 20 times. Distortion of the flexible extensions is acceptable if, after 24 hours, they return to their original shape and position.

19 Moisture Absorption Test

19.1 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 19.2.

19.2 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.

20 10-Day Moist Ammonia-Air Stress Cracking Test

20.1 After being subjected to the conditions described in 20.2 – 20.4, a brass part containing more than 15 percent zinc shall not show evidence of cracking when examined using 25X magnification.

20.2 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 assessed to a 6-inch (152-mm) length of the maximum rated size conductor and torqued to the value specified in 7.4.4.

20.3 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 approximately 12 by 12 by 12 inches (305 by 305 by 305 mm) having a glass cover.

20.4 Approximately 600 ml of aqueous ammonia 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).

MARKING

21 Details

21.1 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.

21.2 A connector shall be plainly marked with the:

a) Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified – hereinafter referred to as manufacturer's name,

b) A distinctive catalog number or the equivalent, and

c) The conductor size or ranges of sizes.

Exception: In lieu of the requirements in (b) or (c) or both, a connector that is for use only with conductors smaller than No. 8 AWG (8.4 mm^2) may be marked with a single identifying symbol. This symbol may consist of an individual catalog number, a type designation, a size designation, such as 12, or an equivalently significant symbol. Each unit container containing connectors so identified or an information sheet packed in the unit container shall be marked with the information indicated in (a), (b), and (c).

21.3 A type designation is intended primarily to identify a particular design, which may include various features covered by different catalog numbers.

21.4 A connector intended only for use with aluminum conductor shall be plainly marked with the letters ″AL.″ A connector intended for use with aluminum or copper-clad aluminum and copper conductor shall be plainly marked ″AL-CU″ or ″CU-AL″. A connector intended for use with copper-clad aluminum and copper conductor shall be plainly marked ″CC-CU″ or ″CU-CC″.

Exception: The markings may be printed on the unit container or on an information sheet packed in the unit container for a connector to be used with No. 6 AWG (13.3 mm^2) or smaller conductors.

21.5 A connector intended for intermixing between conductor types shall be additionally marked ″(intermixed - dry locations)″ immediately following the marking in 21.4, for example AL7CU (intermixed - dry locations). See 3.6.

21.5 effective October 16, 1998

21.6 If a connector is intended for use with aluminum conductor, copper-clad aluminum conductor, or both, 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 aluminum conductor, the copper-clad aluminum conductor, or both; and also the size or range of sizes of copper conductor, for which the connector is acceptable.

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

21.8 Connectors additionally rated for No. 2 AWG (33.6 mm^2) and larger compact-stranded copper shall have the connector, the unit container, or an information sheet packed in the unit container marked ″For compact-stranded copper conductors″ or the equivalent.

21.8 revised May 22, 2000

21.9 A connector tested with solid or stranded conductor other than as indicated in 6.1.10 shall be marked ″Solid″ or ″Stranded″ or with both markings as appropriate. See 21.10.

21.10 The ″Solid″ and ″Stranded″ markings mentioned in 21.9:

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

b) May be printed on the unit container or on an information sheet packed in the unit container, only if there is not adequate space on the connector for either the complete or the abbreviated marking.

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

21.12 The conductor-size marking, if required, on a connector intended for assembly to a conductor or conductors by means of a specific tool may consist of a single symbol, provided that the significance of the symbol, in terms of a conductor size or sizes, is clearly marked on the tool.

21.13 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– If a connector is intended to be assembled 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,

2) On the unit container in which the connector is packed, or

3) On an information sheet packed within the unit container 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 appear either:

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

2) On the tool or pressing die that must be used for its application,

3) On the carrying case provided for permanent storage of the tool and dies, or

4) On the connector.

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

c) CONDUCTOR STRIP LENGTH – Strip length marking as specified in Table 21.1 shall appear:

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

2) On the connector,

3) On an insulating cover, or

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

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

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

d) PRELIMINARY PREPARATION OF CONDUCTOR REQUIRED – Instructions for preparation of the conductors, such as use of compound or twisting conductors together before assembly, shall appear on the unit container in which the connector is packed, on an information sheet packed in the unit container, or on the carrying case provided for permanent storage of the tool. See 7.2.10.

Table 21.1
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] X indicates marking is required.
[b] Strip length may be specified as a single – nominal – value if tested as specified in 7.2.9.
[c] Strip length marking optional if the connector is provided with an open end opposite the conductor insertion end through which the end of the conductor is visible after it is connected.
[d] Strip length marking is optional if 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.

21.14 A specific tool and a removable part of such a tool, such as a pressing die, shall be permanently marked with an identification that can be used for the selection and the proper use of the tool. See 21.13.

21.15 An insulated connector shall be marked with the applicable voltage rating for which it has been found acceptable. The marked voltage rating shall be: ″300 volts maximum,″ ″600 volts maximum,″ or ″600 volts maximum, building wiring: 1000 volts maximum, signs or lighting fixtures (luminaires),″ or equivalent wording. The word ″(luminaires)″ is optional.

Exception: The marking may be on the unit container or on an information sheet packed in the unit container.

21.15 effective August 25, 1997

21.16 A connector shall be marked with the connector temperature rating – 75°C or 90°C – for which it was tested in the heat-cycling test. For a connector with integral insulation, the temperature rating shall not exceed the temperature rating of the insulation. See Secureness-of-Insulation Test, Section 15.

Exception No. 1: For a connector intended for conductor size No. 6 AWG (13.3 mm^2) or smaller, the marking may be on the unit container or on an information sheet packed in the unit container.

Exception No. 2: A 7 may be used to represent a 75°C marking and a 9 may be used to represent a 90°C marking. For a connector marked for use with only aluminum, the single digit shall follow the letters; for example, ″AL7.″ The 7 or 9 shall be incorporated in place of the dash in a marking such as ″AL-CU″ or ″CU-AL″; for example, ″AL7CU″ or ″CU7AL″.

21.17 Installation instructions specifying the proper assembly procedures as mentioned in 7.1.6 and for the securing hardware mentioned in Exception Nos. 1 and 2 to 9.3.1 shall be provided on the unit container in which the connector is packaged or on an information sheet packed in the unit container.

21.18 A blank tang connector (no mounting hole) shall be provided with installation instructions specifying:

a) The minimum mounting hole size or range and the mounting hole location or,

b) The connector tang is to be welded.

The installation instructions shall be on the unit container in which the connector is packaged or on an information sheet packed in the unit container.

21.19 If the manufacturer assigns a value of tightening torque as described in the exception to 7.4.4, the assigned value used in conducting the static-heating sequence tests shall be marked where readily visible on the:

a) Connector,

b) Unit container, or

c) An information sheet packed in the unit container.

21.20 A connector with an assigned ampere rating – see 6.2.2 – shall be marked with the assigned ampere rating; for example, ″100A.″

Exception: For a connector intended for conductor sizes No. 6 AWG (13.3 mm^2) or smaller, the marking may be on the unit container or on an information sheet packed in the unit container.

21.21 An ampere-rated connector shall be marked according to 21.2, 21.4, and 21.16. See 21.20.

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

a) Manufacturer’s name, and

b) A distinctive catalog number of the connector or the equivalent if the marking is provided as specified in 21.24.

21.23 A cover of an insulated splicing connector shall be marked with the:

a) Manufacturer’s name,

b) A distinctive catalog number or the equivalent,

c) The voltage rating – see 21.15, and

d) The operating-temperature limit – see 21.16.

Exception: The voltage rating, (c), and operating-temperature limit, (d), may be marked on the unit container if such container is also marked as specified in (a) and (b).

21.24 The information in a marking shall not be divided between a unit container and an information sheet. If any of the required markings specified in 21.4, 21.5; 21.10 (b); and 21.13, 21.15, 21.16, 21.19, and 21.20, are placed:

a) On the unit container, or

b) On the information sheet packed in the unit container,

rather than on the connector, then all applicable markings as specified in the paragraph in their entirety shall be so placed.

Exception: A unit container of ten or fewer connectors may be marked with a reference to an identifying number on an information sheet as described in 21.25.

21.25 The information sheet mentioned in 21.24 shall be marked with the manufacturer's name, an identifying number as mentioned in the exception to 21.24, the catalog number of the connector to which it pertains or equivalent and with all the necessary information required by 21.10(b), 21.13, 21.15, 21.16, 21.19, and 21.28. The information sheet– one for each unit container – shall be packed in the packaging container.

21.25 revised May 23, 2001

21.26 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.

21.26 added May 22, 2000

21.27 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.

21.27 added May 22, 2000

21.28 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 4.8.1.

21.28 added May 23, 2001