



ANSI C119.4-2011

American National Standard
for Electric Connectors—

Connectors for Use Between Aluminum-to-Aluminum
and Aluminum-to-Copper Conductors Designed for
Normal Operation at or Below 93°C
and Copper-to-Copper Conductors Designed for
Normal Operation at or Below 100°C

Secretariat:

National Electrical Manufacturers Association

Approved March 30, 2011

American National Standards Institute, Inc.

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

ANSI standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While NEMA administers the process to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards and guideline publications.

NEMA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NEMA disclaims and makes no guaranty or warranty, express or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NEMA does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guide.

In publishing and making this document available, NEMA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is NEMA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA has no power, nor does it undertake to police or enforce compliance with the contents of this document. NEMA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety-related information in this document shall not be attributable to NEMA and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

Caution Notice: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published by

**National Electrical Manufacturers Association
1300 North 17th Street, Rosslyn, VA 22209**

© Copyright 2011 by National Electrical Manufacturers Association.

All rights reserved including translation into other languages, reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Printed in the United States of America

< This page intentionally left blank. >

Contents

| | | |
|-------|---|----|
| | Foreword | vi |
| 1 | Scope and Purpose | 1 |
| 1.1 | Scope | 1 |
| 1.2 | Purpose..... | 1 |
| 1.3 | Definitions | 1 |
| 2 | Referenced Standards | 2 |
| 3 | Test Conditions..... | 2 |
| 3.1 | General | 2 |
| 3.2 | Current Cycle Tests | 2 |
| 3.3 | Thermal Stability of All Copper Systems | 3 |
| 3.4 | Mechanical Tests | 3 |
| 4 | Performance Requirements | 3 |
| 4.1 | General | 3 |
| 4.2 | Sample Failure..... | 3 |
| 4.3 | Current Cycle Resistance Stability | 3 |
| 4.3.1 | CCT | 3 |
| 4.3.2 | CCST | 3 |
| 4.4 | Current Cycle Temperature Stability | 3 |
| 4.4.1 | CCT | 4 |
| 4.4.2 | CCST | 4 |
| 4.5 | Copper System Thermal Stability | 4 |
| 4.5.1 | Thermal Stability | 4 |
| 4.5.2 | Determination of Thermal Stability..... | 4 |
| 4.6 | Tensile Strength and Rated Conductor Strength | 5 |
| 4.6.1 | Tensile Strength | 5 |
| 4.6.2 | Rated Conductor Strength | 5 |
| 4.6.3 | Classes of Tensile Strength | 5 |
| 4.7 | Tap Connector | 5 |
| 4.8 | Tee Connector | 6 |
| 4.9 | Wye Connector | 6 |
| 4.10 | Bolt Tightening..... | 6 |
| 4.11 | Reusable Connectors | 6 |
| 4.12 | Substantive Change to a Product..... | 6 |
| 5 | Test Procedures, General | 6 |
| 5.1 | Connector Family Sample Set..... | 6 |
| 5.2 | Test Conductors | 6 |
| 5.3 | Test Assembly Methods | 7 |
| 5.3.1 | Conductor Preparation for Electrical Tests | 7 |
| 5.3.2 | Conductor Preparation for Mechanical Tests | 7 |
| 5.3.3 | Connector Preparation | 7 |
| 5.3.4 | Connector Installation | 7 |
| 6 | Current Cycle Test Procedures | 7 |
| 6.1 | General | 7 |
| 6.2 | Test Assembly | 7 |
| 6.2.1 | Conductors..... | 7 |
| 6.2.2 | Connectors..... | 8 |
| 6.3 | Equalizers | 8 |
| 6.4 | Conductor Lengths | 8 |
| 6.5 | Control Conductor..... | 8 |
| 6.5.1 | Equivalent Aluminum/Copper Conductors | 8 |
| 6.5.2 | Multiple Control Conductors..... | 8 |
| 6.6 | Loop Configuration and Location..... | 9 |

ANSI C119.4-2011

| | | |
|---------|---|----|
| 6.6.1 | CCT Method..... | 9 |
| 6.6.2 | CCST Method | 9 |
| 6.7 | Ambient Conditions..... | 9 |
| 6.8 | Test Current..... | 9 |
| 6.8.1 | CCT Current and Temperature Conditions | 9 |
| 6.8.2 | CCST Current and Temperature Conditions | 9 |
| 6.9 | Current Cycle Period | 9 |
| 6.9.1 | CCT and CCST Current Cycle-ON Period..... | 10 |
| 6.9.2 | CCT Current Cycle-OFF Period..... | 10 |
| 6.9.3 | CCST Current Cycle-OFF Period | 10 |
| 6.10 | Measurements | 10 |
| 6.10.1 | Temperature Measurements..... | 10 |
| 6.10.2 | Resistance Measurements | 10 |
| 6.11 | Maximum Number of Current Cycles | 11 |
| 7 | Mechanical Test Procedures..... | 11 |
| 7.1 | General | 11 |
| 7.2 | Test Connectors | 11 |
| 7.3 | Pullout Test..... | 11 |
| 7.3.3 | Tensile Strength..... | 11 |
| 7.3.3.1 | Sustained Load | 11 |
| 7.3.4 | Maximum Load..... | 12 |
| 7.4 | Bolt Tightening Test..... | 12 |
| 7.5 | Conductor Damage Test..... | 13 |
| 8 | Copper System Stability Test..... | 13 |
| 9 | Test Report..... | 13 |
| 10 | Connector Marking | 14 |
| 11 | Installation Instructions..... | 14 |

Annexes

| | | |
|---------|--|----|
| Annex A | Heat Cycle Data Sheet..... | 28 |
| Annex B | Applicable Standards | 29 |
| Annex C | Suggested Thermocouple Locations..... | 31 |
| Annex D | Optional Fault Current Test Class “F” Connectors..... | 32 |
| Annex E | Optional Corrosion Test Addition to Current Cycle Test (CCT) Class “S” Connectors..... | 38 |

Tables

| | | |
|----------|--|----|
| Table 1 | Test Duration..... | 15 |
| Table 2 | Resistance and Temperature Measurement Intervals..... | 15 |
| Table 3 | Tensile Force, AWG Wire | 16 |
| Table 4 | Tensile Force, mm ² Wire..... | 16 |
| Table 5 | Tightening Torque, Inch Size Fasteners | 17 |
| Table 6 | Tightening Torque, Metric Size Fasteners..... | 17 |
| Table 7 | Conductor Lengths for Current Cycle Tests, AWG/kcmil Sizes..... | 18 |
| Table 8 | Conductor Lengths for Current Cycle Tests, mm ² Sizes | 18 |
| Table 9 | Suggested Initial Test Current to Raise AWG/kcmil Control Conductor Temperature 100°C (212°F) Above Ambient..... | 19 |
| Table 10 | Suggested Initial Test Current to Raise mm ² Control Conductor Temperature 100°C (212°F) Above Ambient..... | 20 |
| Table 11 | Minimum Current-ON Duration for AWG/kcmil Control Conductors..... | 20 |
| Table 12 | Minimum Current-ON Duration for mm ² Control Conductors | 20 |
| Table 13 | Length of Exposed Conductor | 21 |

Figures

Figure 1 Length of Projected Conductor 22
Figure 2 Horizontal Schematic 23
Figure 3 Tap Schematic 24
Figure 4 Wye Schematic 25
Figure 5 Vertical Configuration..... 26
Figure 6 Copper System Stability Schematic..... 27

Worksheet

Current Cycle Data Sheet 28

Foreword (Neither this foreword nor any of the informative annexes is a part of American National Standard C119.4-2011)

This standard describes electrical and mechanical tests used to establish performance characteristics of connectors used to join aluminum-to-aluminum, aluminum-to-copper, or copper-to-copper bare and insulated conductors.

It is the responsibility of the user to determine the proper connector for any particular application. The user may request the manufacturer to perform any additional desired testing beyond that required by the C119.4-2011 standard performance tests.

Substantive changes to the standard have been made in the C119.4-2011 version of the standard. A substantive change is one that directly and materially affects performance of a product and which requires testing or retesting to meet the current edition of a standard. The substantive changes to the standard are as follows:

1. Test requirements for copper connectors.
2. Test requirements for copper system stability, which were not part of earlier editions.
3. Requirement for retesting performance of a product if there have been substantive changes made to the product.

This revision includes the addition of spreadsheet files in Annex A that can be used to collect current cycle test data, calculate connector stability, generate graphs of the data, and print data to provide test results as part of the test report. The spreadsheets are provided to give a standardized format to collect, calculate, and report test data and test results. These spreadsheets were not part of earlier editions.

This revision includes the addition of two optional tests: Optional Fault Current Test (Annex D) and Optional Corrosion Test (Annex E). These optional tests are not a part of the required C119.4-2011 standard performance tests. The subcommittee has provided these optional performance tests as references in response to users who have requested guidance for these types of additional performance tests. The user may request that the manufacturer perform any additional tests that are not a part of the required C119.4-2011 standard performance tests.

This standard includes an additional current cycle test method (CCT) utilizing elevated temperature testing for an extra heavy duty connector category, Class AA. The intent of elevated test temperature in Class AA testing is to provide a better performing connector. There is also a new class of tensile strength—Class 1A, Normal Tension.

This standard includes an alternate, accelerated current cycle test method, henceforth referred to as the current cycle submersion test (CCST). The CCST method differs from the traditional current cycle test (CCT) in that test conductors are rapidly cooled by immersion in chilled water at the beginning of the “current-OFF” cycle, and the test requires fewer total current-ON and current-OFF cycles. Comparative testing has demonstrated that the CCST method will provide essentially the same performance test results as the traditional current cycle test (CCT) in fewer test cycles. The current cycle test remains the preferred test method recommended for qualification of a connector.

This standard was initially developed under the direction of the Transmission and Distribution Committee of the Edison Electric Institute (EEI). Tentative performance-type specifications for electrical characteristics were issued in joint report form in 1958 by a steering committee of EEI and an advisory committee of manufacturers on the aluminum conductor research project (EEI Pub. No. 59-70 *Tentative Specifications for Connectors for Aluminum Conductors*).

Experience gained from extensive trial use further confirmed the performance criteria and test conditions of the tentative specifications and led to the development of Standard TDJ 162 in October 1962 by a joint committee of EEI and the National Electrical Manufacturers Association (NEMA). TDJ 162 was subsequently superseded by this document.

The C119.4 Subcommittee of the Accredited Standards Committee on Connectors for Electric Utility applications, C119, in its constant review of the publication, continues to seek out the views of responsible users that will contribute to the development of better standards. Suggestions for improvement of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Connectors for Electrical Utility Applications, C119. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C119 Committee had the following members:

Douglas Harms, Chairperson

Ronald Lai, Vice Chairperson

Paul Orr, Secretary

Organization Represented

Aluminum Association
Electric Utility Industry

Jean-Marie Asselin
Michael Dyer
Warren Hadley
Douglas Harms
James Harris
Harry Hayes
Alan Kasanow
J.C. Mathieson
Jesus Rodriguez
Curt Schultz
Gerald Wasielewski
David West
Michael Zaffina
Paul Springer

National Electric Energy Testing Research &
Applications Center
National Electrical Manufacturers Association

Jason Bundren
Scott Casler
Barry Johnson
Ronald Lai
John Makal
Colin McCullough
Michael Miloshoff
Greg Nienaber
Wayne Quesnel
Carl Taylor
James Zahnen
Giovanni Velazquez
Craig Pon
Chris Morton
Trung Hiu
Jeffrey Nelson
Jake Killinger
Peter Bowers
Tip Goodwin
Stanley Hodgkin
John Olenik
Joe Renowden
Carl Tamm
Allen Wilcox

CFE LAPEM
Kinectrics Inc.
Powertech Labs Inc.
Rural Utilities Service (RUS)
Tennessee Valley Authority
Underwriters Laboratories Inc.
Other

ANSI C119.4-2011

The C119.4 Subcommittee on Connectors for Use Between Aluminum-to-Aluminum and Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93°C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100°C, which developed the revisions of this standard, had the following members at the time of its approval:

Douglas Harms, Chairperson

Ronald Lai, Vice Chairperson

Vince Baclawski, Secretary

Jean-Marie Asselin

Peter Bowers

Jason Bundren

Scott Casler

Michael L. Dyer

Tip Goodwin

Joseph Graziano

Warren C. Hadley

Douglas Harms

H. L. Hayes III

Trung Hiu

Barry Johnson

Alan Kasanow

Ronald Lai

John M. Makal

J.C. Mathieson

Colin McCullough

Michael Miloshoff

Richard Morin

Greg T. Nienaber

John Olenik

Craig Pon

Wayne Quesnel

Joe Renowden

Jesus Rodriguez

Curt Schultz

Paul Springer PE

Carl Tamm

Carl Taylor

Giovanni Velazquez

Richard (Jeff) J. Waidelich

Gerald Wasielewski

David West

Allen Wilcox

Michael Zaffina

James Zahnen

For Electric Connectors—

Connectors for Use Between Aluminum-to-Aluminum and Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93°C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100°C

1 Scope and Purpose

1.1 Scope

This standard covers connectors used for making electrical connections between aluminum-to-aluminum or aluminum-to-copper or copper-to-copper conductors used on distribution and transmission lines for electric utilities.

This standard establishes the electrical and mechanical test requirements for electrical connectors. This standard is not intended to recommend operating conditions or temperatures.

1.2 Purpose

The purpose of this standard is to give reasonable assurance to the user that connectors meeting the requirements of this standard will perform in a satisfactory manner, provided they have been properly selected for the intended application and are installed in accordance with the manufacturer's recommendations. The service operating conditions and the selection of the connector class is the responsibility of the user.